6E103

E-506

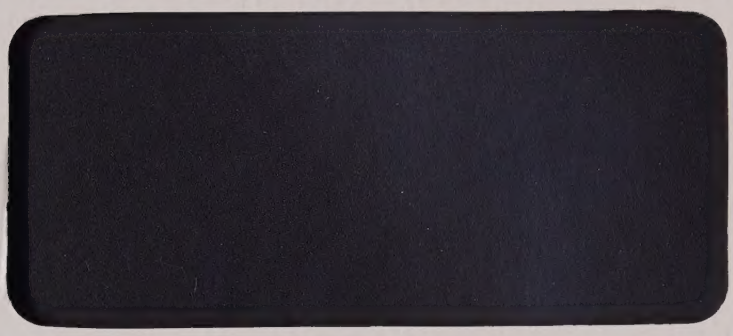
sweep oscillator

640 SERIES

Serial ____ ____

ALFRED

SINGER
INSTRUMENTATION



INSTRUCTION MANUAL

sweep oscillator

640 SERIES

Serial ____ ____

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SECTION 1 - INTRODUCTION

1.1 SPECIFICATIONS

MODEL	FREQUENCY RANGE	MINIMUM POWER OUTPUT	POWER VARIATION LEVELED	RESIDUAL FM MAXIMUM	VSWR	RF CONNECTOR
641 641K	1 to 2 Gc	70 mw	± 0.3 db	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
641-S1 641K-S1	1.4 to 2.5 Gc	70 mw	± 0.3 db	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
642-S1	1.7 to 4.2 Gc	30 mw	± 0.3 db	25 Kc peak	Less than 2.5 : 1	Type 'N' Female
642 642K	2 to 4 Gc	50 mw	± 0.3 db	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
643-S1 643K-S1	3.5 to 6.75 Gc	20 mw	± 0.5 db	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
643-S2 643K-S2	3.7 to 8.3 Gc	10 mw	± 0.6 db	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
643 643K	4 to 8 Gc	20 mw	± 0.5 db	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
644 644K	7 to 11 Gc	10 mw	± 0.5 db	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
644-S1 644K-S1	7.0 to 12.4 Gc	10 mw	± 0.75 db	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
645 645K	8 to 12.4 Gc	20 mw	± 0.5 db from 8.2 to 12.4 Gc	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	UG135/U Flange
646	10 to 15.5 Gc	10 mw		100 Kc peak	Less than 2.5 : 1	WR75 Flange
647 647K	12.4 to 18 Gc	10 mw	± 1.0 db	100 Kc peak unleveled. 200 Kc peak leveled.	Less than 2.5 : 1	UG419/U Flange
648	18 to 26.5 Gc	10 mw		250 Kc peak	Less than 2 : 1	UG595/U Flange
649	26.5 to 40 Gc	5 mw		400 Kc peak	Less than 3 : 1	UG599/U Flange

RF Output:	Model 640 Series; rf output is unleveled. Rf sampler for external leveling available to 12.4 Gc. Model 640K Series; rf output is either leveled or unleveled. Rf sampler is internal. Rf sampler for external leveling available to 12.4 Gc.
Frequency Control:	Five controls; F_0 , F_1 , F_2 , M_1 and M_2 continuously adjustable over entire frequency range. All five can be used for single frequency operation and are calibrated to better than 1%.
Frequency Stability:	Better than 0.01% per degree centigrade.
Markers:	M_1 , M_2 and F_0 continuously adjustable over entire frequency range. Markers appear as a reduction in rf power. Amplitude of markers is adjustable to zero. Width is less than 0.05% of frequency range when power reduction is 10% or less.
Wide Sweep: ($F_1 \rightarrow F_2$)	F_1 sets start frequency, F_2 sets end frequency. Width continuously adjustable from 2% to 100% of the full frequency range.
Symmetrical Sweep: ($F_0 \pm \Delta F$)	F_0 sets the center frequency of the symmetrical narrow sweep. ΔF continuously adjustable from 0 to ± 5% of the frequency range about any F_0 setting.
Sweep Rate:	Continuously adjustable from 0.01 to 100 seconds per sweep.
Sweep Trigger:	Four modes; EXTERNAL, FREE RUN, LINE and MANUAL (single sweep). A signal of 10 μsec. duration or longer with an amplitude of at least + 2 volts will trigger the sweep. In LINE mode the sweep is triggered at the input line frequency or a sub-multiple thereof.
Amplitude Modulation:	Three modes; EXTERNAL, OFF and internally generated SQUARE WAVE. Square wave symmetry within 5%. Frequency continuously adjustable between 800 and 1200 cps. Rise time is less than 15 μsec. leveled, less than 1 μsec. unleveled.

	External +10 volt signal turns on rf to level determined by power level control. Input impedance is 10 K Ω. Rise time is less than 15 μsec. leveled, less than 1 μsec. unleveled. Input is dc coupled.
	External positive signal can give rise times of less than 0.5 μsec. in unleveled pulse mode. The signal modulates the grid of the backward wave oscillator from cutoff to maximum power. Input impedance (pulse) is approximately 5 K Ω shunted by 100 pf. Input is dc coupled to the modulator and ac coupled to the grid of the backward wave oscillator. Amplitude of signal depends on backward wave oscillator grid characteristics; 75 volts is maximum required. (Most bands require approximately 25 volts.)
Frequency Modulation:	Externally applied signal of 1.5 volts, peak to peak, produces a 10% deviation of full frequency range. Positive going voltage increases frequency. FM can be applied during all modes of operation. Response; dc to 10 Kc. Input impedance; 15 K Ω.
Leveler Input:	-100 mv into 3 K Ω required for rated rf output.
Sweep Output:	Zero to 15 volts sawtooth during $F_1 \rightarrow F_2$ and $F_0 \pm \Delta F$ sweep modes. Zero to 15 volt dc signal depending upon frequency setting when operating at F_0, M_1 or M_2 in the SINGLE FREQUENCY mode. Output impedance is 10 K Ω.
Blanking Output:	A +50 volt signal is available during sweep retrace. Output impedance is 10 K Ω.
Recorder Calibrate:	A +15 volt signal is available at the SWEEP OUTPUT jack when the RECORDER CALIBRATE button is depressed.
Power Level:	In LEVELED mode the power level is adjustable over a 10 db range. In UNLEVELED mode the power level is continuously adjustable from zero to maximum tube capability.
Power Input:	105 to 125 volts or 210 to 250 volts; 50/400 cps; 150 VA.
Dimensions:	See Figure 1-1.
Weight:	Approximately 60 pounds.

1.2 DESCRIPTION

The ALFRED 640 Series Sweep Oscillator is a general purpose microwave signal source utilizing a voltage tuned backward wave oscillator tube. The tube is powered by low drift, low ripple, precisely regulated power supplies.

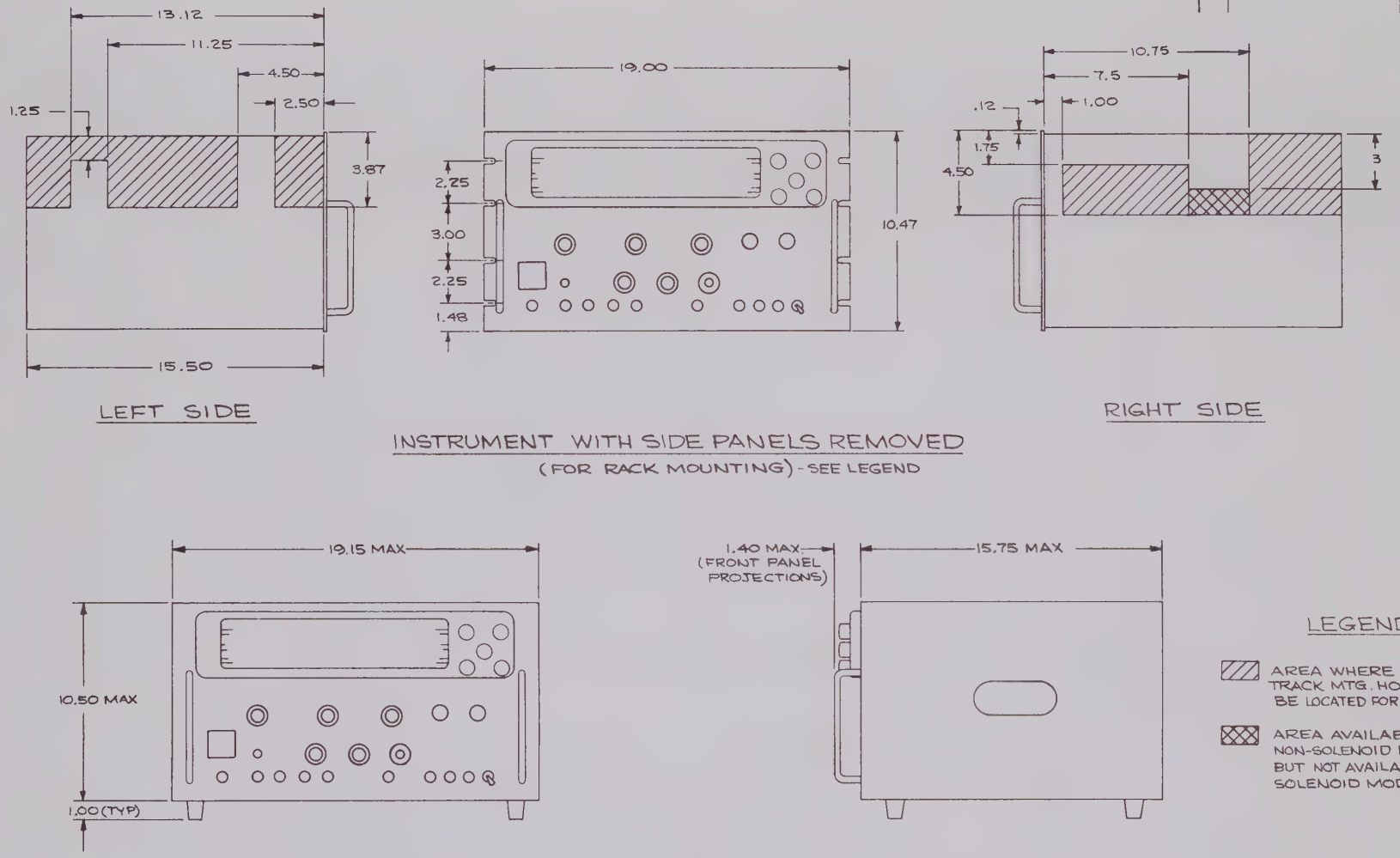
The rf output can be modulated by either an externally applied am or fm signal or by an internally generated square wave. The square wave frequency is continuously adjustable from 800 to 1200 cps. An externally generated pulse can be capacitively coupled to the backward wave oscillator grid for fast am rise time.

Leveling of the rf output is accomplished by a closed loop circuit. A crystal diode supplies a voltage which is proportional to the rf power. This voltage is compared to a stable dc reference voltage. The difference, or error voltage, is then amplified and applied to the grid of the backward wave oscillator so that power output variations can be continuously corrected.

Three frequency markers are provided. They are short, triangular, negative pulses which modulate the rf. The pulse width is less than 0.05% of the total frequency range andthe amplitude is adjusted by a front panel control.

For X-axis drive of oscilloscopes and recorders, a linear, positive going 15 volt sweep voltage is available. A front panel push button provides the +15 volt signal in all modes of operation for end point reference. A +50 volt signal is available for recorder pen blanking while a front panel control selects rf on or off during sweep retrace.

The backward wave oscillator tube used in the 640 does not require rf adjustment, is encapsulated for protection, and is easily replaced. Test points are provided on the rear of the unit to monitor electrode currents and voltages. Protective circuits reduce the likelihood of damage to the tube.



NOTES:

1. THE MODEL 640 SERIES INSTRUMENT MAY BE EITHER BENCH MOUNTED OR RACK MOUNTED.
2. FOR RACK MOUNTING REMOVE BOTH SIDE PANELS.
3. FOR INSTALLATION OF CHASSIS TRACKS, DRILL MTG. HOLES ONLY IN SHADED AREAS INDICATED ABOVE.
4. APPROXIMATE WEIGHT OF INSTRUMENT IS 60 LBS. (SLIGHTLY HEAVIER FOR SOLENOID MODEL INSTRUMENTS).

FIGURE 1-1

SYM	DESCRIPTION	NO.	DATE	BY

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

NEXT ASSY	USED ON
	640 SERIES

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN Dave Presley DATE

ENG G. Oshima

PROD

SCALE 1:4

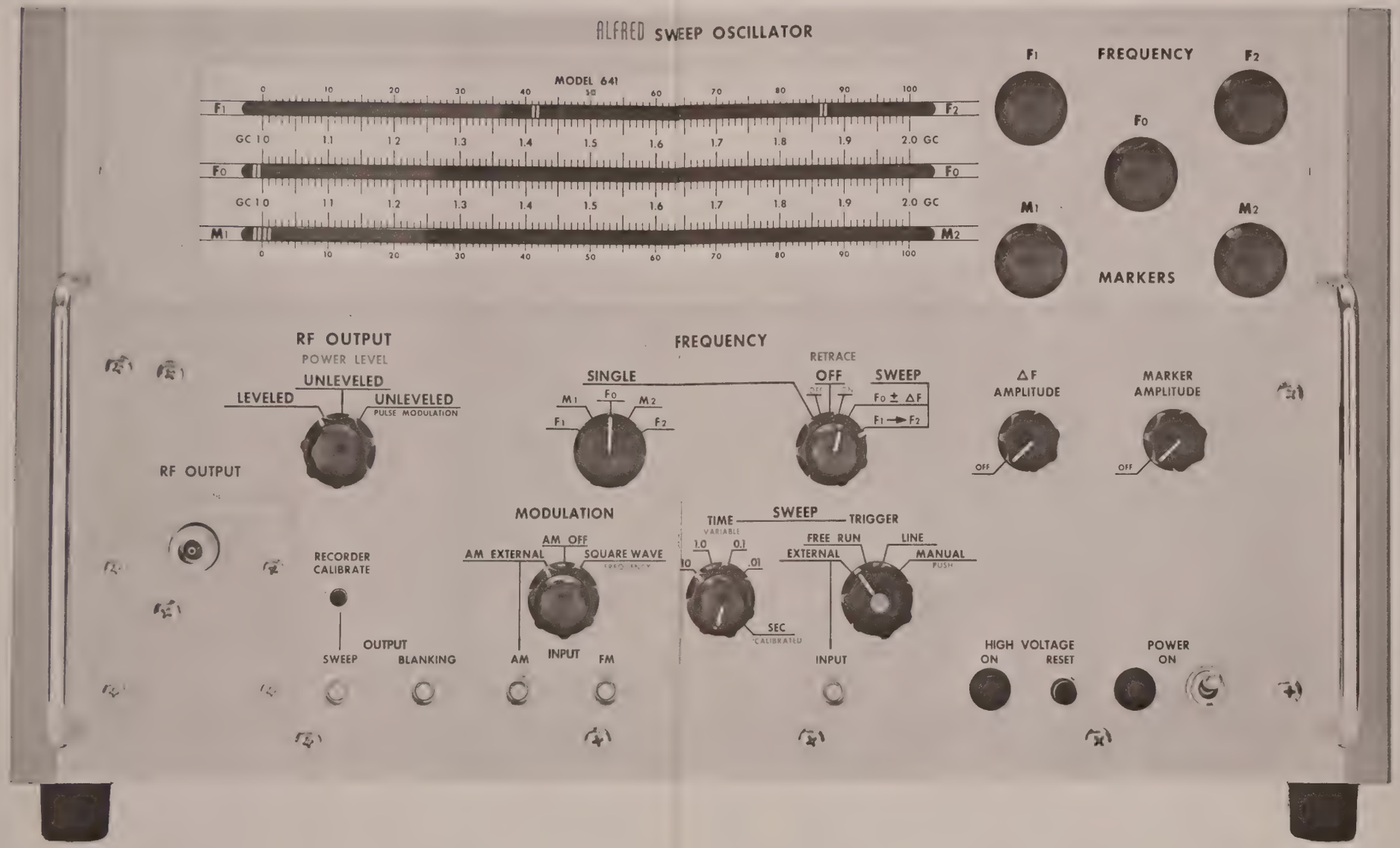
OUTLINE & DIMENSIONAL DATA FOR MODEL 640 SERIES INSTRUMENT

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

990125C

SHEET 1 OF 1



FRONT PANEL

FIGURE 2-1

SECTION 2 - OPERATING INSTRUCTIONS

2.1 FRONT PANEL CONTROLS

A. FREQUENCY CONTROLS: Located to the right of the calibrated dial are three frequency controls: F_1 , F_0 , and F_2. They are used in conjunction with the three frequency indicators and the calibrated dial to set the desired frequencies.

B. MARKER CONTROLS: Below the three frequency controls are two marker controls: M_1 and M_2. They are used in conjunction with the two marker indicators and the calibrated dial to set the desired marker frequencies. In the $F_1 \rightarrow F_2$ mode, F_0 is also a marker.

C. FREQUENCY MODE SELECTOR - RETRACE CONTROL

FREQUENCY MODE SELECTOR

$F_1 \rightarrow F_2$: In this position the rf output is swept from the F_1 frequency indicator setting to the F_2 frequency indicator setting. The sweep frequency range (from F_1 to F_2) can be varied from 100% to 2% of the frequency band of the oscillator. When in this mode marker pips are provided at the F_0, M_1 and M_2 frequency settings and a sawtooth sweep voltage of 15 volts amplitude is available at the SWEEP OUTPUT jack.

$F_0 \pm \Delta F$: In this position the rf output is swept symmetrically about any F_0 frequency setting. ΔF can be varied from 5% of the band to zero. The $F_0 \pm \Delta F$ mode can be used to examine small perturbations seen when using the $F_1 \rightarrow F_2$ mode. To do this set the F_0 marker pip at the perturbation frequency and change the mode from $F_1 \rightarrow F_2$ to $F_0 \pm \Delta F$. When in this mode, marker pips are provided at the M_1 and M_2 frequency settings and the 15 volt sawtooth is available at the SWEEP OUTPUT jack.

OFF: When in this position the backward wave oscillator is biased off and no rf appears at the output. In single frequency operation the OFF position is used to zero external meters and establish a zero power reference. If the instrument is to be left on but in a standby condition the FREQUENCY mode selector should be in the OFF position.

SINGLE: In this position the oscillator output can be one of five single frequencies determined by the F_0 , F_1 , F_2 , M_1 or M_2 indicators. The SINGLE FREQUENCY switch determines which frequency indicator controls the output frequency.

In both the F_1 and F_2 positions a voltage is provided at the SWEEP OUTPUT jack. In the F_1 position zero volts is provided while at F_2 +15 volts is provided. These voltages can be used to set the start and end points of oscilloscopes and recorders. In the F_0 , M_1 and M_2 positions, a voltage is provided at the SWEEP OUTPUT jack which is a function of the frequency and can be used to control the X-axis of X-Y recorders.

D. RETRACE CONTROL: Concentric with the FREQUENCY mode selector, this control is operative only in the SWEEP modes, i. e., $F_0 \pm \Delta F$, $F_1 \rightarrow F_2$. In the OFF position, the rf is off during retrace.

E. RF OUTPUT CONTROL:

LEVELED: In this position the rf output is maintained constant across the frequency band. The output level is set by the concentric POWER LEVEL control and has a 6 db control range.

UNLEVELED: In this position the rf output can be adjusted from zero to maximum tube capability at any point in the band by the POWER

LEVEL control. Since the maximum leveled output is generally less than the tube capability, this mode allows more rf output than the LEVELED mode.

UNLEVELED - PULSE MODULATION: In this position the rf can be modulated by an external signal applied through the AM INPUT jack. The signal is capacitively as well as dc coupled to the backward wave oscillator grid and allows fast rise time. The rf signal is unaffected by the POWER LEVEL control and remains at its maximum output level.

F. MODULATION CONTROL

AM EXTERNAL: When in this position and the RF OUTPUT control is in the LEVELED or UNLEVELED position, a positive 10 volt signal applied to the AM INPUT jack will turn the rf on to the level set by the POWER LEVEL control. When the RF OUTPUT control is in the UNLEVELED PULSE mode, a positive signal whose magnitude depends upon the BWO tube used turns the rf on to maximum power.

AM OFF: When in this position, the rf output is unmodulated.

SQUARE WAVE: In this position the rf output is modulated by an internally generated square wave whose frequency can be varied between 800 and 1200 cycles per second by the SQUARE WAVE FREQUENCY control which is concentric with the MODULATION control.

G. SWEEP TIME CONTROL: This control sets the time to sweep from the start frequency (F_1) to the end frequency (F_2) while in the $F_1 \rightarrow F_2$ sweep mode and the time to sweep from $F_0 - \Delta F$ to $F_0 + \Delta F$ in the $F_0 \pm \Delta F$ sweep mode. There are four major settings: .01, 0.1, 1.0 and 10 seconds. A concentric knob allows continuous intermediate settings up to 100 seconds. When the concentric knob is full clockwise, the sweep time is calibrated to the value indicated by the SWEEP TIME control.

H. SWEEP TRIGGER CONTROL

EXTERNAL: When in this position, a positive signal applied to the EXTERNAL TRIGGER INPUT jack will trigger the sweep. The amplitude must be at least +2 volts and the width at least 10 microseconds.

FREE RUN: In this position the sweep is triggered immediately upon the completion of a cycle.

LINE: In this position the sweep trigger is synchronized to the input line frequency or a sub-multiple of the line frequency, depending upon the setting of the sweep time control.

MANUAL: In this position the sweep is triggered by pressing the concentric button.

I. Δ F AMPLITUDE CONTROL: This control varies the width of the symmetrical sweep about F_0 when the FREQUENCY mode selector is in the $F_0 \pm \Delta F$ mode. In full clockwise position the width is at least $\pm$ 5% of the frequency band.

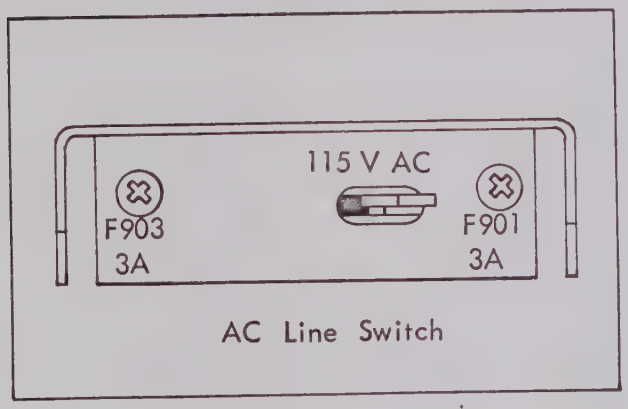
J. MARKER AMPLITUDE CONTROL: This control sets the amplitude of the marker pulses that are visible in the swept rf output. The type of circuit used results in a pulse whose width is also reduced as the amplitude is reduced.

K. HIGH VOLTAGE RESET: If for some reason the helix current limitation of the backward wave oscillator is exceeded, the high voltage will automatically turn off. If correct adjustments are made and the reset button is pressed, high voltage will be restored.

L. RECORDER CALIBRATE BUTTON: A +15 volt signal is available at the SWEEP OUTPUT jack when the RECORDER CALIBRATE button is depressed. This signal is available in all modes and is used to set up recorders and oscilloscopes. At the start of any sweep, the sweep output is always zero volts and at the end of any sweep, it is always +15 volts.

2.2 INITIAL TURN-ON

2.2.1 POWER REQUIREMENTS



AC Line Switch

Figure 2-2

The unit is normally connected at the factory for operation at 105 to 125 volts and 50 to 400 cycles ac (115 volts nominal). However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 400 cycles ac (230 volts nominal). With the top cover removed, locate the power switch plate labeled 115 VAC. (See Figure 2-2.) By removing and reversing this plate, the switch can be moved to the left. Replace the plate with 230 volts ac showing. Replace the eight ampere main fuse (in back of instrument) with a six ampere fuse.

2.2.2 INITIAL TURN-ON PROCEDURES

Prior to regular operation of the unit, the following test should be performed:

1. Set FREQUENCY mode selector to SINGLE; F_0.
2. Set FREQUENCY indicator F_0 to the low end of the scale (0 on logging scale).
3. Set MODULATION control to AM OFF.
4. Set RF OUTPUT to UNLEVELED and rotate the POWER LEVEL control to the maximum CW position.
5. Connect a millivoltmeter to TP18 and TP19 located in the rear of the instrument. These test points are calibrated to supply 10 mv/ma into a load greater than 1 K. Move switch S913, located below TP18 and TP19, to the HELIX/DELAY LINE position. See Chart 5-1 for full scale readings.
6. Turn power switch to ON.

   NOTE: Time delay relays delay high voltage turn on for approximately 60 seconds after the POWER switch is turned ON to allow a brief warm up period for the backward wave oscillator filament. If the AC power is off for only an instant, the normal 60 second delay will occur before high voltage returns.
7. When the high voltage appears, measure the helix current on the meter. The helix current should be less than that specified in Chart #1, Section 5. Move switch S913 to the COLLECTOR position. Observe the collector current. The value should be between 5 and 15 ma. (For acceptable values see tube data sheet located in envelope at rear of manual.)
8. With tubes that have delay lines (no collector) switch S913 should be set to the HELIX/DELAY LINE position. Current values of these tubes should be between 10 and 40 ma.
9. The collector or delay line current can vary from instrument to instrument and therefore no definite value is established. (See tube data

sheet, located in envelope at rear of manual for complete data on the tube in your instrument.) If the backward wave oscillator currents are correct, the unit is ready for operation.

2.3 OPERATING PROCEDURE

Turn POWER switch to ON. After high voltage appears, the instrument is ready for operation.

For wide sweep operation, the FREQUENCY mode selector is set to $F_1 \rightarrow F_2$ and the F_1 and F_2 FREQUENCY indicators are set to the desired start and end frequency points. The SWEEP TIME and SWEEP TRIGGER controls are adjusted to the desired time and trigger conditions.

For narrow sweep operation the FREQUENCY mode selector is set to SWEEP; $F_0 \pm \Delta F$ and the F_0 FREQUENCY indicator is used to set the desired frequency.

The ΔF AMPLITUDE control can be adjusted to the $\pm \Delta F$ sweep width desired. A maximum value of at least ± 5% of the frequency band of the instrument is available.

Example: Frequency band of instrument = 2 to 4 Gc
Band Coverage = 2 Gc
5% of 2 Gc = 100 Mc (maximum ΔF)

When sweeping in either the wide or narrow sweep modes, markers are available by turning up the MARKER AMPLITUDE control. In the $F_1 \rightarrow F_2$ mode there are three markers available whose frequencies are set by the F_0, M_1, and M_2 control knobs. In the $F_0 \pm \Delta F$ mode two markers are available: M_1 and M_2.

During either wide or narrow sweep a sawtooth waveform whose amplitude is + 15 volts peak is provided at the SWEEP OUTPUT jack. Also provided is a + 50 volt pulse at the BLANKING OUTPUT jack which occurs during retrace and is controlled by the concentric RETRACE control.

For single frequency operation the FREQUENCY mode selector can be set to SINGLE; F_0, F_1, F_2, M_1 or M_2 and the frequency desired set by the F_0, F_1, F_2, M_1 or M_2 control knob. For manual sweep, the FREQUENCY mode selector is set to SINGLE; F_0 and the F_0 control knob is used to sweep the frequency manually. During manual sweep a dc voltage which is a function of the F_0 frequency is available at the SWEEP OUTPUT jack.

The rf power output can be either leveled, unleveled or unleveled-pulse modulated by selecting the applicable mode with the RF OUTPUT control. The LEVELED mode provides a constant rf power output across the frequency band, whereas, in the UNLEVELED mode the rf power output can be adjusted from zero to maximum tube capability by the concentric POWER LEVEL control.

2.4 REMOTE FREQUENCY CONTROL

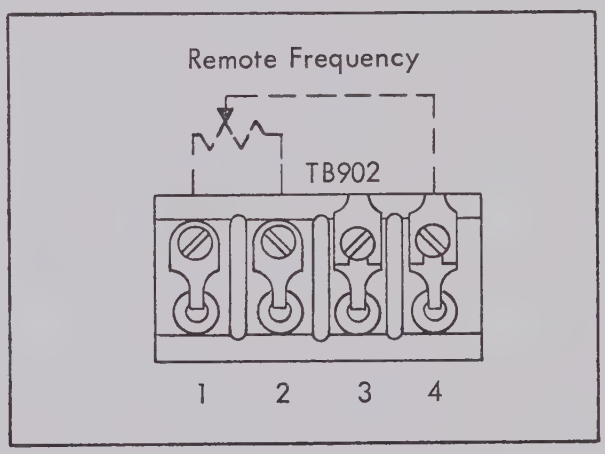


Figure 2-3

If it is desired to control the F_0 FREQUENCY at some distance from the instrument, terminal block TB902, located at the rear of the instrument, is provided for this purpose. See Figure 2-3.

Remove the jumpers at TB902, -3 and -4 and insert a 1 K Ω potentiometer as indicated by the dotted lines.

NOTE: Shielded wires should be used to connect the external 1 K Ω potentiometer to the terminal. (A shielded three wire cable is satisfactory.)

2.5 EXTERNAL LEVELING

External leveling of the rf output is used advantageously when the load to be tested cannot be connected directly to the 640 unit. By locating the rf sampler at the load, transmission line and component discontinuities are contained within the leveling loop and are compensated. When more power is required, a microwave amplifier can be included inside the leveling loop.

The Model 640 Series Microwave Oscillator may be externally leveled by sampling the signal from the rf output and applying the detected signal to the INPUT LEVELER jack. This signal should be approximately -100 mv.

The Model 640K Series Microwave Oscillator is internally leveled. The installation of "Option 7" provides the additional capability for external leveling. External leveling is accomplished by sampling the signal from the rf output and applying the detected signal to the INPUT LEVELER jack. This signal should be approximately -100 mv.

SECTION 3 - CIRCUIT DESCRIPTION

3.1 GENERAL

See Block Diagram, Figure 3-12.

The high frequency rf energy produced by the unit is generated by a backward wave oscillator tube. The tube is controlled by stable power supplies. Through proper voltage control the backward wave oscillator provides a means of producing either a variable frequency (sweep mode) or a stable frequency (single mode).

The rf output frequency of the backward wave oscillator tube is primarily determined by the voltage difference between its cathode and helix. Since the tube helix is grounded through a small value resistor, the cathode supply determines the rf output frequency. The backward wave oscillator can be operated continuously at a fixed frequency or may be repeatedly swept over any part of its operating frequency range. An internal sweep generator, whose ramp output drives the cathode supply, provides this sweeping feature. Since the backward wave oscillator frequency vs. cathode voltage function is non-linear, the cathode supply is made non-linear so as to make the output frequency a linear function of the sweep voltage.

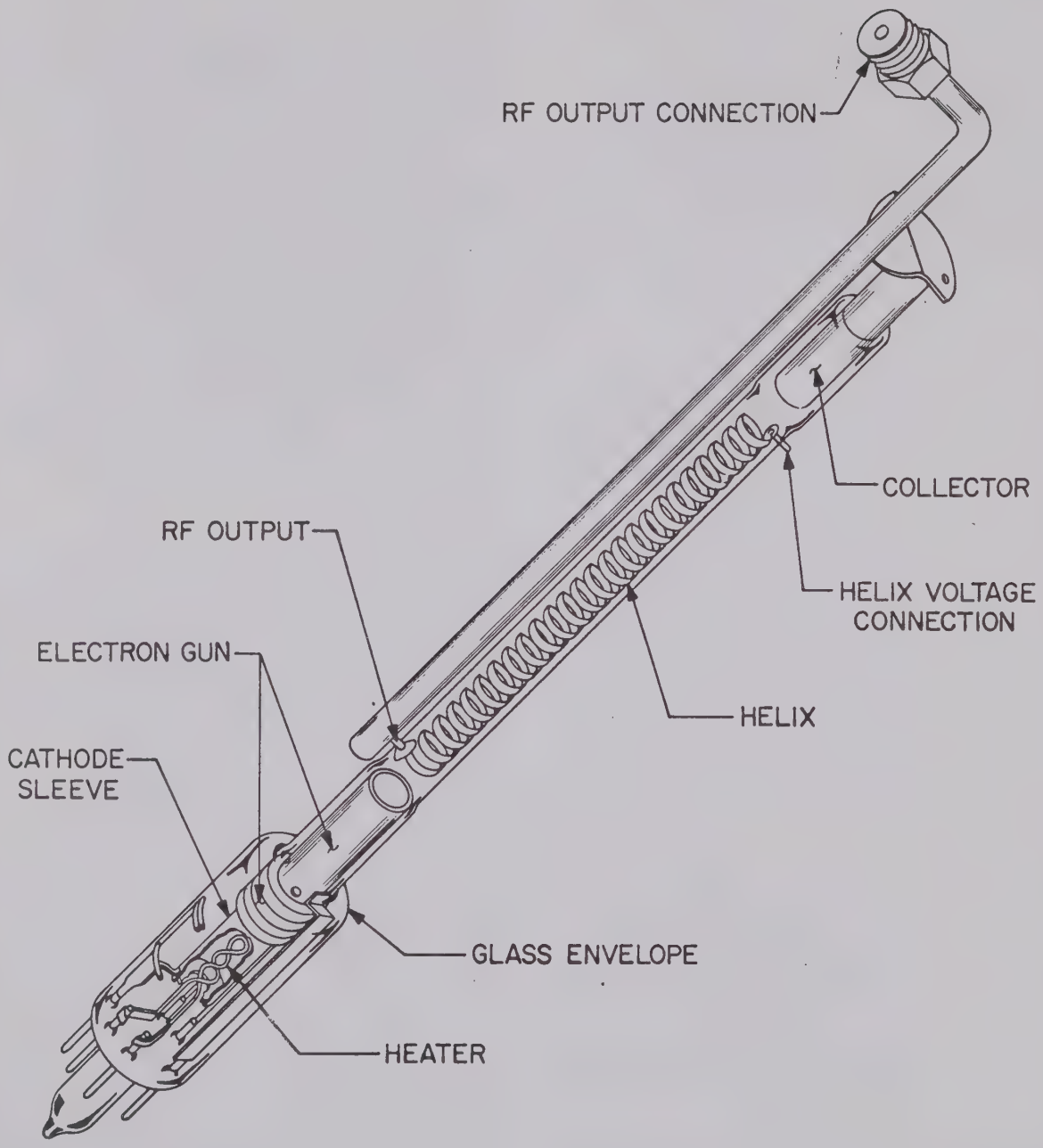
Because the power output of the backward wave oscillator varies over its frequency range, a leveler system is used to hold the rf power output constant. The unit can also be operated unleveled to obtain the maximum power output of the tube.

3.2 THE BACKWARD WAVE OSCILLATOR TUBE

The backward wave oscillator tube consists of an electron gun, a slow wave structure and a collector at the far end of the slow wave structure. The rf output of the tube is produced by the interaction between the electron beam and the electromagnetic field of a microwave signal developed on the slow wave structure. See Figure 3-1.

The electron gun contains a heated cathode and two or more aperture disc type control electrodes which help form the beam and control beam density. In a helix backward wave oscillator, it is desirable to have a hollow cylindrical electron beam since only the electrons that pass adjacent to the helix are fully effective in delivering energy to the wave. Electrons near the middle of the beam consume anode power but contribute little or nothing to the energy interchange that produces the backward wave oscillations. Surrounding the tube is a magnet which produces a strong axial field. This field focuses the electrons in the beam and allows movement only in the direction of the axis of the tube.

Oscillations, and hence the rf wave, begin in the backward wave oscillator in much the same manner as they begin in other oscillators. Noise waves are established on the helix from the shot noise coupled from the electron beam and from thermal energy developed at the input end of the tube. Waves are produced which travel in both directions in the helix, i. e., from gun to collector and from collector to gun. Since the desired wave in a backward wave oscillator must travel from the collector to the gun end, attenuators are placed in the tube which eliminate the forward moving waves. Amplification of the wave is produced by the interaction of the electrons in the beam and the electromagnetic field of the wave. To obtain this interaction, the electron beam must be at some critical velocity which is achieved by applying a dc voltage to the helix. Because the electromagnetic field is alternating, electrons in the beam are subjected to either an accelerating or decelerating field. Thus, the electrons entering the helix experience velocity modulation with a tendency for a bunch of electrons to be formed as they move through the helix. The critical areas of interaction are the spaces between the helix turns because the



BACKWARD WAVE OSCILLATOR TUBE
FIGURE 3-1

axial electric field is strong between helix turns and weak under the turns.

To explain the bunching process let us examine a group of electrons as they travel from the gun to the collector end of the tube. Within this group there will be one electron, e, which corresponds to the zero point of the alternating axial field and is therefore unaffected by the signal on the helix. See Figure 3-2A. This electron experiences no acceleration from the electromagnetic field. However, an electron just to the left of e, e', encounters a positive axial field and is accelerated thus tending to catch up with e. Similarly, electron e", which is just to the right of e, encounters a negative or decelerating field and so slows down and tends to be overtaken by electron e. The electrons centered about e are thus velocity modulated. This situation is repeated over and over again as the electrons centered about the reference electron pass one space after another. Now, by choosing the electron velocity so that at the collector end of the tube the phase difference between the wave and bunches in the beam is approximately one half cycle, the electron bunches will encounter relatively strong decelerating fields as they cross the spaces. Thus, the kinetic energy of the electrons is transferred to the backward wave. The amplitude of the backward wave builds up as it progresses toward the gun end of the tube because it passes more and more bunches from which it receives energy. At the same time, the alternating component of the beam current, i. e., the bunching becomes greater as the electrons progress toward the collector. See Figure 3-2B.

The operating frequency range of a particular backward wave oscillator tube is primarily determined by the dimensions of the slow wave structure. Since the most commonly used slow wave structure is a helix the following discussion will be based on this type of tube.

It is well known that a slow wave structure will propagate a particular range of frequencies at constant axial velocity (the non-dispersive region) and above that range, the axial velocity of propagation increases with frequency (the dispersive region). The backward wave oscillator operates in the dispersive region and it will oscillate at the frequency for which the beam velocity is very nearly equal to the axial velocity of propagation. Figure 3-2C shows the variation of propagation velocity with frequency for a particular helix while Figure 3-2D shows how the beam velocity varies with the helix to cathode voltage.

From these figures it can be seen why the backward wave oscillator can be voltage tuned. By changing the helix to cathode voltage, the beam velocity changes and the frequency for which the velocity of propagation and the velocity of the beam are in synchronism changes. The helix dimensions, primarily diameter and pitch, are chosen so that the tuning voltages required for a particular frequency range are reasonable (usually about 200 to 2000 volts).

3.3 +15 AND -15 VOLT POWER SUPPLIES

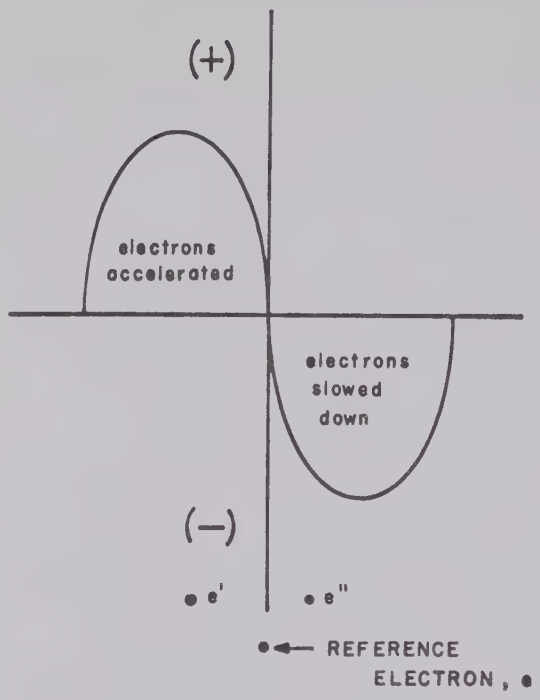
See Figure 3-3.

The +15 and -15 volt power supplies provide the reference voltages for the unit. The primary reference for the unit is A2CR1, a 1N823A temperature compensated zener diode. This diode is used as the reference for the -15 volt supply.

The -15 volt supply consists of a two stage differential amplifier, a driver, and a series regulator transistor. The amplifier consists of an input differential stage A2Q8; A2Q6 and A2Q7 the second differential stage and A2Q5 the driver for the series regulator transistor Q904.

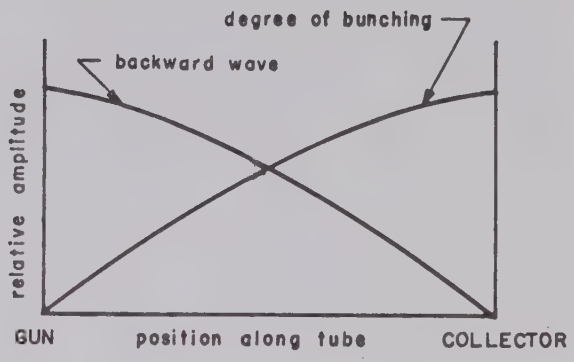
The use of metal film resistors in all critical circuits and matched transistors in the input stage at A2Q8, minimizes noise and drift in this supply. As in all closed loop feedback systems, tight control of phase response must be maintained. This is accomplished in this circuit by A2C5and A2R34 located at the collector of A2Q6.

The -15 volts applied to A2R10 is used as the



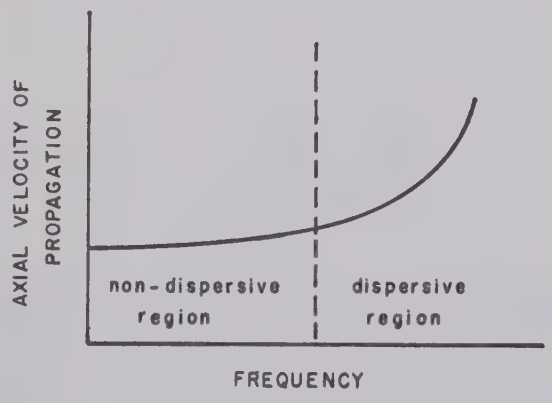
ELECTRON DISTRIBUTION

(A)



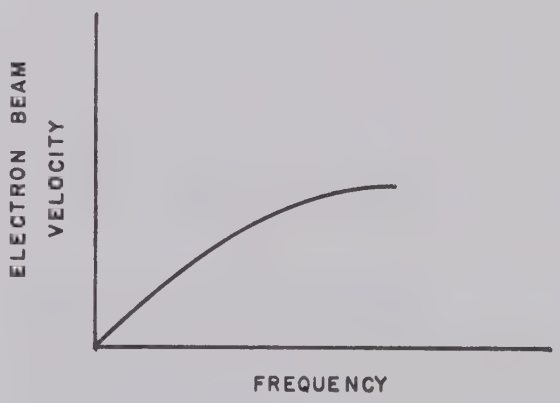
RELATIVE AMPLITUDE VS. POSITION ALONG TUBE

(B)



AXIAL VELOCITY OF PROPAGATION VS. FREQUENCY

(C)



ELECTRON BEAM VELOCITY VS. FREQUENCY

(D)

— FIGURE 3-2 —

reference for the +15 volt supply. To control the output of the +15 volt supply, a two stage differential amplifier, a driver, and a series regulator transistor are also used. The amplifier consists of an input differential stage A2Q4; A2Q2 and A2Q3 the second stage and A2Q1 the driver stage. Q903 is the series regulator. The main phase response control for the +15 volt supply is A2C2 located across the collector of A2Q4. The -15 volt supply is adjusted by A2R18 and the +15 volt supply is adjusted by A2R9.

3.4 +100 AND -50 VOLT POWER SUPPLIES

The +100 volt supply consists of a single stage differential amplifier A2Q9 and A2Q10, and a driver stage A2Q13, which drives the series regulator transistor Q901. A neon bulb, DS903 protects Q901 during turn-on. The +100 volt supply uses the -15 volt supply as a reference. See Figure 3-4.

The -50 volt supply consists of a two stage amplifier and a series regulator. The amplifier consists of A2Q12 the input stage and A2Q11 the driver. Q905 is the series transistor. The +15 volt supply is the reference for this supply. Phase response is controlled in the second stage by means of A2C10 and A2R37.

Diode A2CR2 is for temperature compensation and diode A2CR3 prevents transients from damaging A2Q12.

3.5 CATHODE SUPPLY

The cathode supply for the backward wave oscillator is an operational amplifier using both tubes and transistors. See Figure 3-5. It consists of a summing junction and a transistorized operational amplifier which controls the grids of the series regulator tubes V901, V902 and V903, located in the rear of the instrument. The summing junction and the operational amplifier are located on PC Board 100. The summing junction is at the base of Q101. A portion of the dc output is fed into the input of the summing junction, through high impedance emitter followers Q109 and Q110, forming a complete feedback system whose output can range from 150 to 2500 volts. The high impedance path makes it unnecessary to use high power resistors, thus minimizing power dissipation and hence thermal drift. Two diodes, CR101 and CR102, are used to compensate for any temperature deviations which occur in the emitter followers. Also in the feedback network is a non-linear, voltage sensitive attenuator consisting of a diode shaping network located on PC Board 900. It causes the output of the cathode supply to become non-linear with respect to its input and thus compensates for the non-linear tuning curve of the backward wave oscillator. Hence, the output frequency is directly proportional to the input voltage of the amplifier. For single frequency operation a voltage directly proportional to the frequency dial indicator position is applied to the amplifier input. During $F_1 \rightarrow F_2$ swept operation a linear varying voltage, supplied by the sweep generator, is applied to the amplifier input. When in the $F_0 \pm \Delta F$ sweep mode a linearly varying voltage, supplied by the sweep generator, starts at $F_0 - \Delta F$ and sweeps to $F_0 + \Delta F$. This sweep voltage is applied to the amplifier input. The external modulation input is also connected to the amplifier input. A 1.5 volt signal will change the frequency by 10% of the band.

Tubes are used as the control elements for the high voltage supply because of their ability to withstand the high voltage required for the cathode of the backward wave oscillator. Transistors were chosen for the preamplifier because of their immunity to microphonics and low power requirements.

3.6 ANODE SUPPLY

The gun structure of all backward wave oscillators contains an anode which collimates the electron beam before it is accelerated to helix potential. The anode operates at an elevated potential with respect to the cathode and may vary from 25 to 250 volts depending upon the tube type. See Figure 3-6. Supply regulation is accomplished by

a shunt regulator circuit consisting of one vacuum tube, which serves as the shunt regulator element, and three transistors. The transistor amplifier drives the shunt regulator tube and is located on PC Board 800. A reference voltage is furnished by the 70 volt grid bias supply. The anode voltage is adjusted by means of R828, the ANODE VOLTAGE ADJUST potentiometer and R831; a coarse adjustment made by changing its value.

3.7 FILAMENT SUPPLY

The filament supply is a regulated, variable, dc supply using a series regulator transistor and a two stage transistor amplifier. See Figure 3-6. The regulator amplifier, consisting of Q801 and Q802, is located on the elevated supplies board, PC 800. A zener diode, CR801, is the supply reference. The output voltage may be adjusted by means of R805, the backward wave oscillator HEATER VOLTAGE ADJUST, located on PC Board 800.

3.8 GRID SUPPLY

The 70 volt grid supply furnishes power to the grid driver amplifier. See Figure 3-6. It is shunt regulated and uses a two stage transistor differential amplifier to drive the shunt regulator transistor, Q803. A zener diode reference, CR802, is used to determine the supply output. Most of the components of this supply are located on PC Board 800.

3.9 SWEEP GENERATOR

The sweep generator is located on PC Board 300 and PC Board 700. The four basic circuits on PC Board 300 are the Miller integrator consisting of Q304-Q307, the trigger circuitry consisting of Q308-Q311, a gating multivibrator consisting of Q301-Q302, and a retrace hold-off circuit consisting of Q312-Q314. See Figure 3-7.

The basic part of the sweep generator is the Miller integrator, a capacitive feedback dc amplifier which integrates its input voltage producing a linearly increasing output. This linear output creates a ramp which is used as the sweep in the instrument. The feedback capacitors for the Miller integrator are C701-C704, located on PC Board 700. The slope of the ramp output of Q307 is determined by the feedback capacitors and resistors R945 and R946.

Prior to the initiation of the sweep, Q301 in the multivibrator is off causing a positive voltage to be fed to the base of Q314. This causes the output of the retrace hold-off circuit Q312 to be positive which places a positive voltage on the base of Q304, the input to the Miller integrator circuit. This holds the output of the Miller integrator circuit, the collector of Q307, at approximately zero volts. A positive trigger applied to the base of Q309, through resistor R319, causes the Schmitt trigger, Q310 and Q311, to switch. The resulting negative spike on the collector of Q311 is fed to the base of Q302 in the multivibrator, through S906, causing the multivibrator to change states. Q302 is now off, or in the non-conducting state, while Q301 is on, or in the conducting state. This causes positive voltage to be removed from the base of both Q314 and Q304. The Miller integrator now generates a ramp function determined by the setting of switch S903, which selects the feedback capacitor and by the adjustment of R946, the SWEEP TIME multiplier control. When the ramp output of Q307 reaches 40 volts, CR302 becomes forward biased placing a positive voltage on the base of Q302, causing the multivibrator to change states. A positive voltage is again applied to the Miller integrator input, through the retrace hold-off circuit, causing the feedback capacitor to rapidly discharge. The Miller integrator output returns to zero volts. Thus, the sweep completes one cycle of operation and is ready for another. The sweep output from Q307 is channeled to the frequency controls through emitter follower Q705. The output of Q705 is also connected to emitter follower Q704, which in turn is connected to the SWEEP OUTPUT jack, J915.

In addition to the ramp output, this circuitry also provides a blanking voltage generated at the collector of amplifier Q303. The input to Q303 is taken from the collector of Q302 in the gating multivibrator circuit. Q303 amplifies the multivibrator output producing a +50 volt pulse which

occurs during retrace and can be used for recorder pen lift or for oscilloscope blanking.

3.10 SWEEP TRIGGER MODES

The Model 640 provides four means of initiating or triggering a sweep. The choice is provided by the front panel SWEEP TRIGGER control whose four positions are FREE RUN, EXTERNAL, LINE and MANUAL. In the FREE RUN position the sweep is self-triggered. When the sweep returns to zero volts CR301 conducts, causing the sweep gate multivibrator to flip into the opposite condition, immediately retriggering the sweep cycle. In the EXTERNAL mode, transistors Q310 and Q311 form a Schmitt trigger which takes any arbitrary input waveform and transforms it into a step function. The step function is differentiated and the resultant spike is fed to CR301 to trigger the sweep. In the LINE mode a 6.3 volt ac rms voltage, at the line frequency, is supplied to the Schmitt trigger thus synchronizing the sweep rate to the power line frequency. In the MANUAL mode the push-button switch connects the Schmitt trigger to the +15 volt supply and allows just one trigger each time the button is depressed.

3.11 MARKER CIRCUIT

Located on PC Board 400, the marker circuit is shown schematically on Figure 3-8. For simplicity, only one of the three identical channels is shown. The marker circuit provides wavemeter-like pips to indicate preset frequencies set by the F_0 , M_1 or M_2 FREQUENCY control knobs. The markers are electronically generated from the sweep. A voltage is summed into the markers by the marker adjusting potentiometers M_1 , M_2 or F_0. The signal applied to the input of the cathode supply is also applied to the marker input. The marker has a condition which depends upon the backward wave oscillator beam voltage or the oscillating frequency of the backward wave oscillator as related to its input voltage. Hence, the same total current is summed into the helix supply and the action of the markers is identical in character to the helix supply. Thus, the marker generated is directly related to the frequency of oscillation of the backward wave oscillator tube.

A marker will appear when the input current corresponding to the frequency of oscillation is balanced by the current from the marker potentiometer. The first three stages of the marker circuit are amplifiers. The fourth stage is a high gain differential amplifier which is activated only when the input current is at the balance point (the point at which the frequency of oscillation is precisely that indicated by the marker). At this point, the voltage on R420 goes from a maximum to a minimum and the voltage on R422 goes from a minimum to a maximum. CR403 and CR404 form a diode adder. The most negative voltage applied to either diode will control the output. Hence, the output is first connected to R422 and then R420. Consequently, the amplifier has a waveform which is triangular in shape. The markers are positioned by potentiometers R932 (F_0), R927 (M_1), and R926 (M_2).

All three marker circuits operate in exactly the same manner. The marker signals, from the three marker circuits, are added together with a dc voltage, which controls their amplitude and the sum is applied to emitter follower Q419, and then to the amplitude modulation circuits.

3.12 LEVELING CIRCUITRY

The function of the leveling circuitry is to hold the power output of the backward wave oscillator constant over its operating frequency range. See Figure 3-9. It consists of three major components: the LEVELER-AMPLIFIER located on PC Board 600, the TRANSFER OSCILLATOR located in a shielded box on the lfet rear chassis of the instrument, and the GRID DRIVER AMPLIFIER located on PC Board 800.

The leveler-amplifier is a four stage differential amplifier consisting of transistors Q601 through Q608. The output of the amplifier is modulated by Q609. Transistors Q611 through Q615 are used to hold the frequency response of the leveler system relatively constant over the frequency range of the

unit. This latter circuit is necessary to compensate for variations in grid sensitivity of the backward wave oscillator.

In the LEVELED mode, the rf power output of the backward wave oscillator is adjustable over at least a 10 db range by the POWER LEVEL control, R938, and is held constant by means of the feedback leveler circuit. The rf output is sampled by means of a directional coupler and is fed to an rf crystal detector. The crystal detector output voltage is applied to the input of the leveler-amplifier where it is compared to a dc reference voltage. The voltage difference between the crystal output and the dc reference is amplified and applied to the grid of the backward wave oscillator. The action of the leveler system causes the crystal output voltage to match the dc reference voltage, thus making the backward wave oscillator power output a direct function of the dc reference voltage of the leveler. Thus, rf power output is determined by the magnitude of the leveler reference voltage which is set by the concentric POWER LEVEL control. Modulation is accomplished by modulating the reference voltage. To insure fast response modulation is also applied to the output of the leveler amplifier through A609.

In the UNLEVELED mode, the power output is continuously adjustable from zero to maximum tube capability by the POWER LEVEL control. Rf sensing is inoperative and feedback is placed around the leveler-amplifier such that the output of the leveler-amplifier is a function only of the leveler reference voltage. The amplifier output and therefore the backward wave oscillator grid voltage are direct functions of the leveler reference voltage. When in this mode, all modulation is applied through Q609. The UNLEVELED mode of operation is normally used to obtain the maximum available rf power from the backward wave oscillator.

In the UNLEVELED PULSE mode, the POWER LEVEL control is bypassed and the leveler reference voltage is switched to a maximum. The AM INPUT jack is capacitively coupled as well as dc coupled to the grid of the backward wave oscillator, permitting external am modulation to be applied to the grid as well as to the leveler. Modulation rise and fall times are determined principally by the speed of the external source. In this mode, the output is fixed and is the maximum available from the tube.

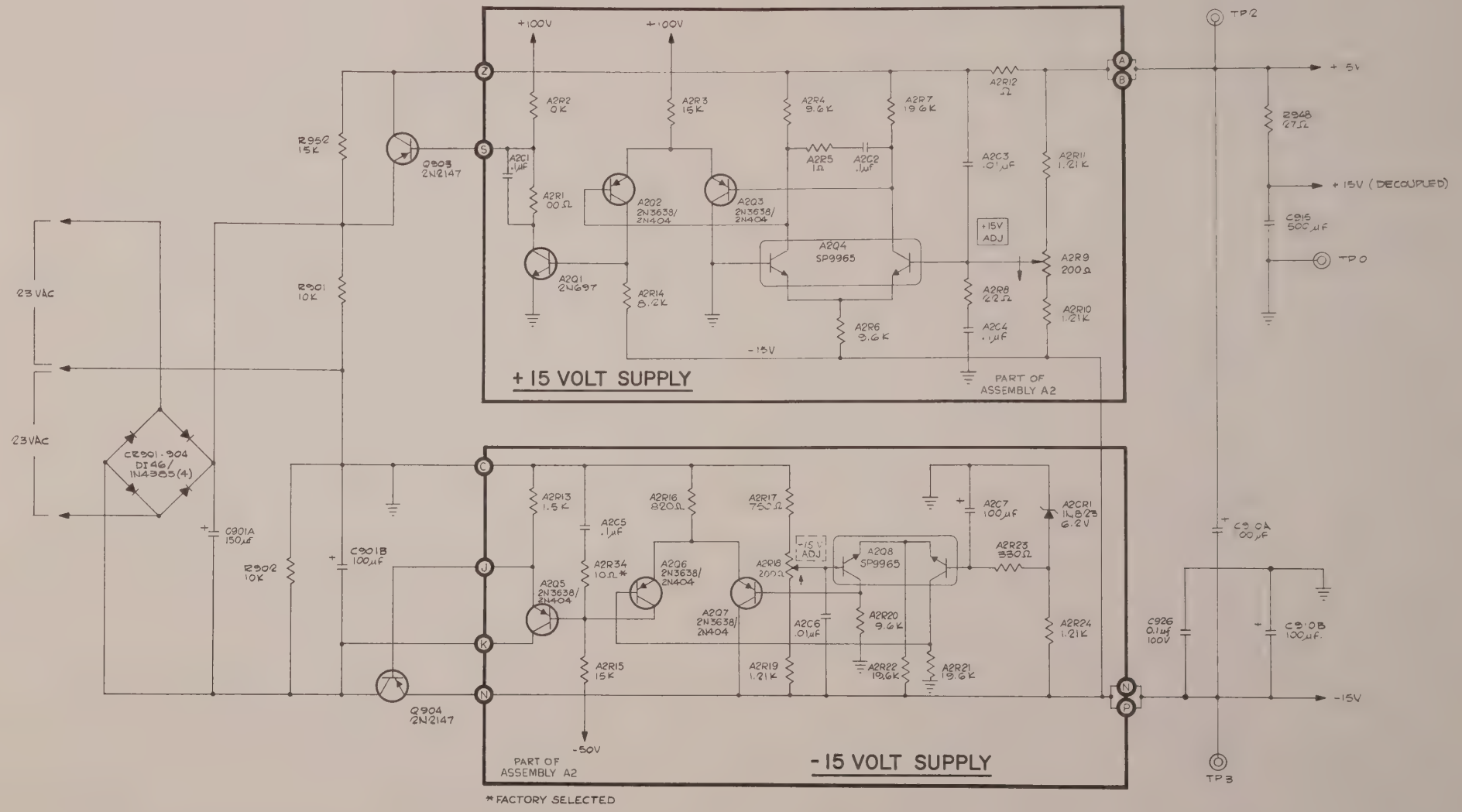
The TRANSFER OSCILLATOR is used as a coupling system permitting the dc output voltage of the leveler-amplifier to be transferred to the elevated grid potential of the backward wave oscillator. The rf output of the amplitude modulated oscillator passes through high voltage capacitors and is detected at the cathode potential of the backward wave oscillator. The dc output of the transfer oscillator detector is amplified by the GRID DRIVER AMPLIFIER and applied between the cathode and grid of the backward wave oscillator. Thus, any dc or modulation signals applied to the input of the transfer oscillator are reproduced on the grid of the backward wave oscillator. This allows all modulation and a greater part of the leveling circuitry to be operated near ground potential.

Transistor Q751 serves as the transfer oscillator while modulation of Q751 is by transistor Q750. The high voltage capacitors which couple the rf output of the transfer oscillator to the detector are C757 and C759. Diodes CR750 and CR751 detect the rf output of the oscillator while Q752 serves as a buffer amplifier. The output of Q752 is filtered and applied to the input of the grid driver amplifier. Q808 and Q809 serve as the grid driver amplifier, the grid of the BWO being connected to the collector of Q808.

3.13 MODULATION CIRCUITRY

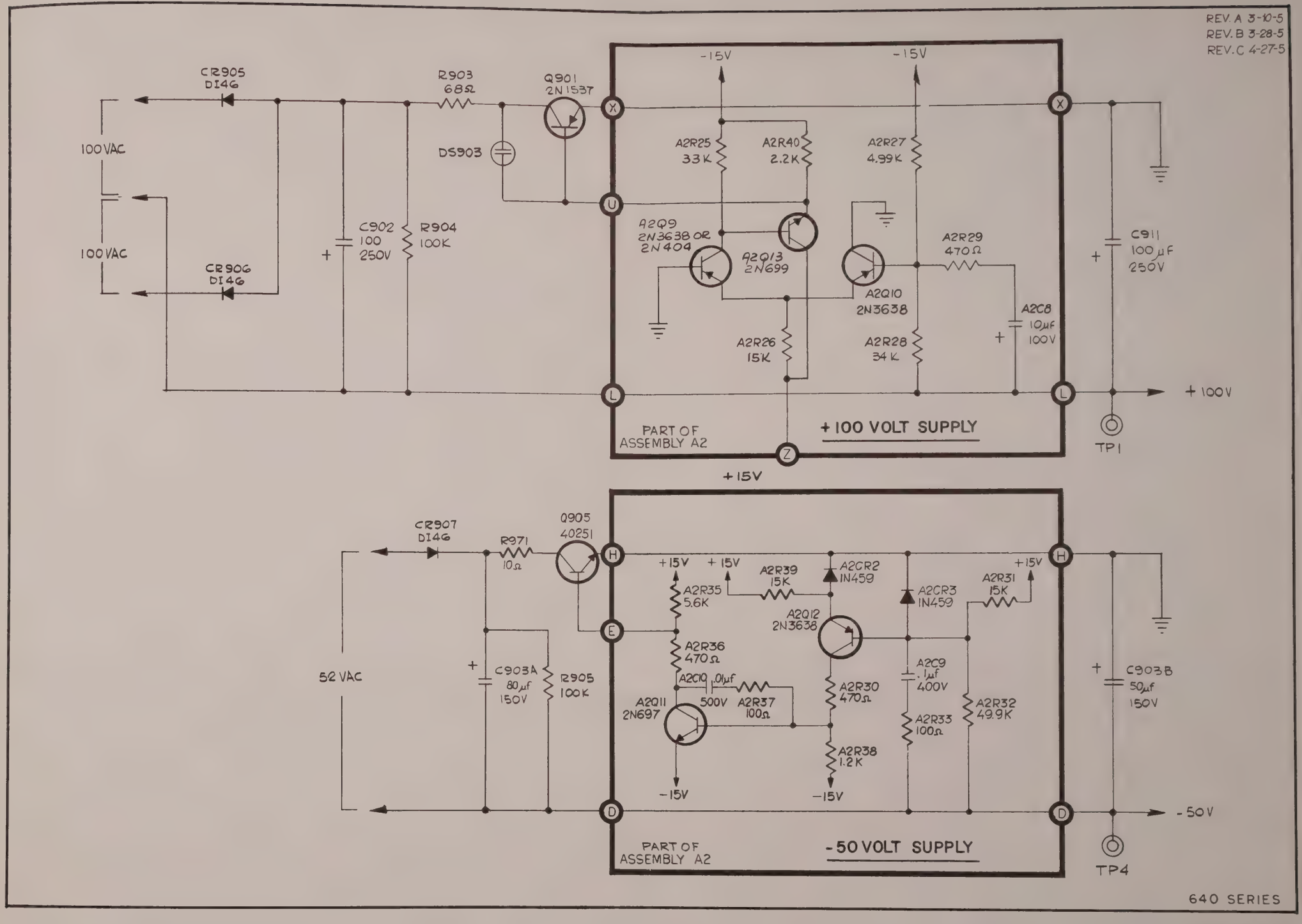
The modulation circuitry, located on PC Board 500, is shown schematically on Figure 3-10. Modulation is accomplished by either an externally applied signal or an internally generated square wave. Square wave voltage is produced by an astable multivibrator consisting of transistors Q501 and Q502 and a bistable multivibrator circuit, Q503 and Q504. The bistable multivibrator insures square wave symmetry and

fast rise and fall time. The square wave frequency can be varied by a front panel control (R937) over a frequency range of 800 to 1200 cps. External modulation is applied to the unit at the AM INPUT jack and is dc coupled to the modulation circuitry. When the MODULATION control is in the AM EXTERNAL position and no signal present at the AM INPUT jack, the backward wave oscillator is cut off. A +15 volt signal, applied to the AM INPUT jack, will turn the tube on to the level determined by the POWER LEVEL control. For fast pulse modulation, the external signal must drive the backward wave oscillator grid from cutoff to zero volts. The voltage required varies from tube to tube but in no case exceeds 75 volts. Other modulation inputs applied to the leveler, through the modulation circuitry, are the markers and blanking modulation. Markers are applied to the leveler reference voltage during leveled operation and to the leveler output through Q309 during unleveled operation. Rf power output can be obtained during sweep retrace by disabling the internal blanking modulation. This is done by placing the RETRACE control to the ON position. Internal SQUARE WAVE, external AM and RF OFF modulation is applied to the leveler through Q505. Marker modulation is applied to the leveler through Q506.

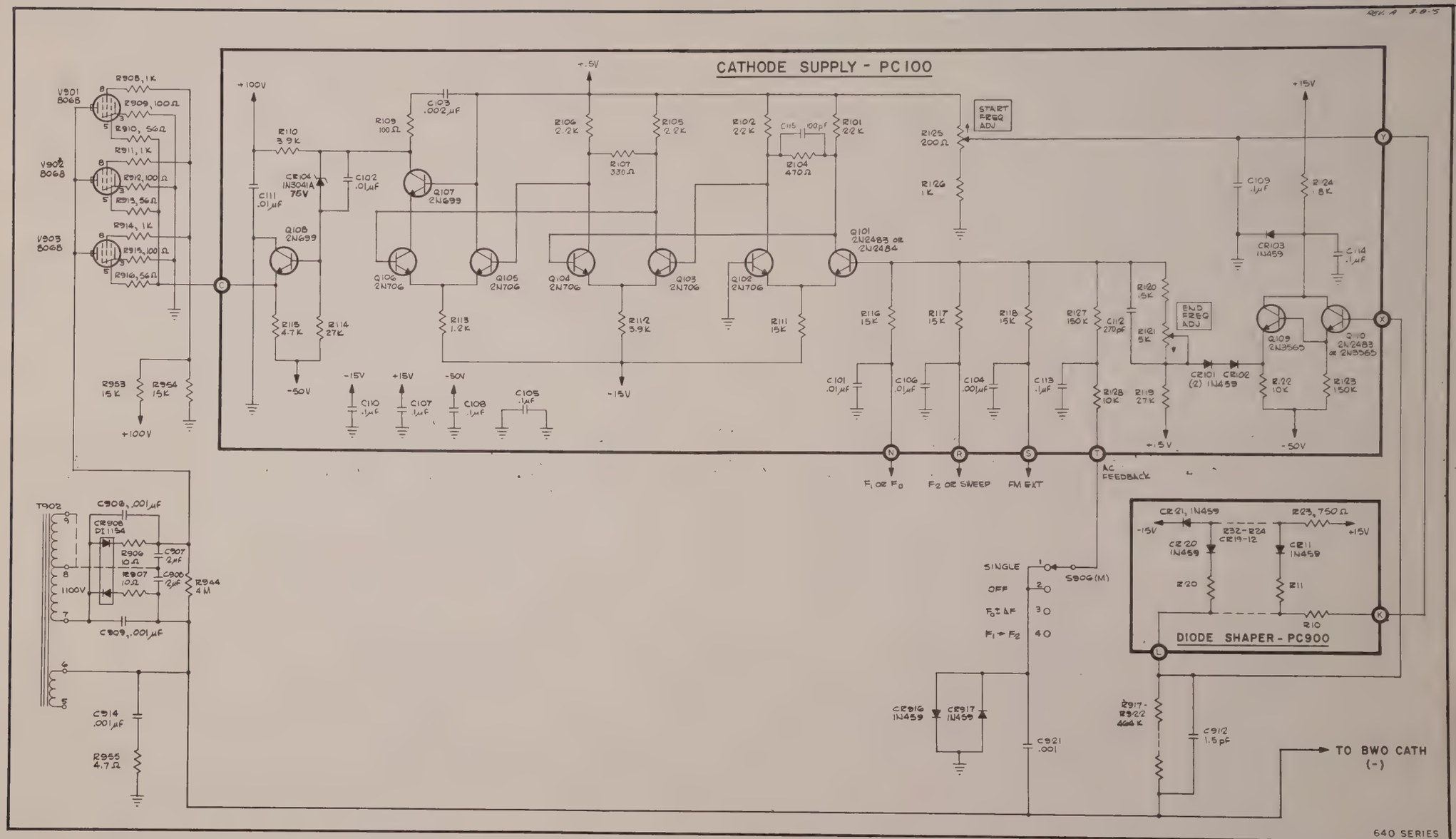


640 SERIES

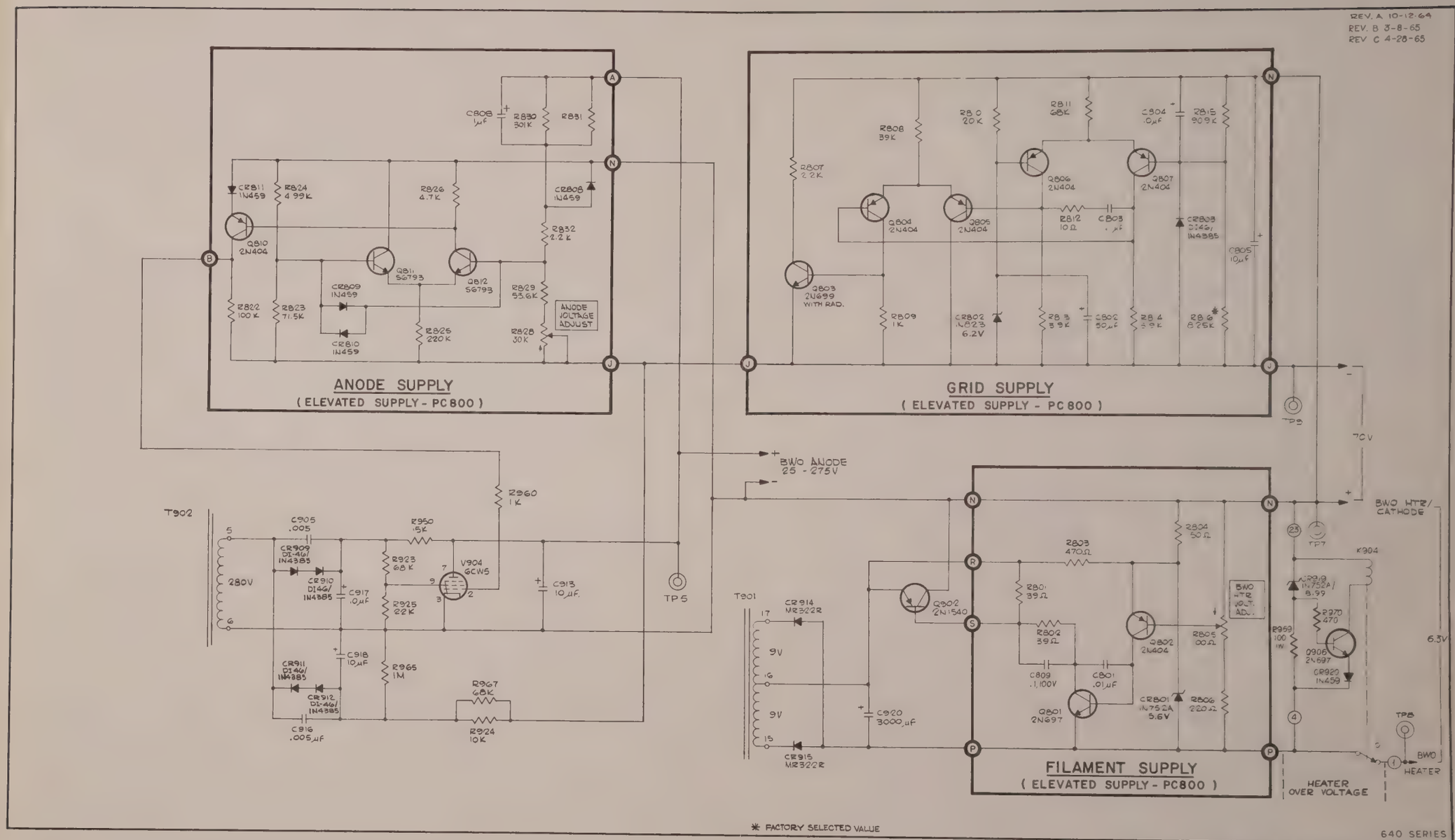
+15,–15 VOLT SUPPLIES
FIGURE 3-3



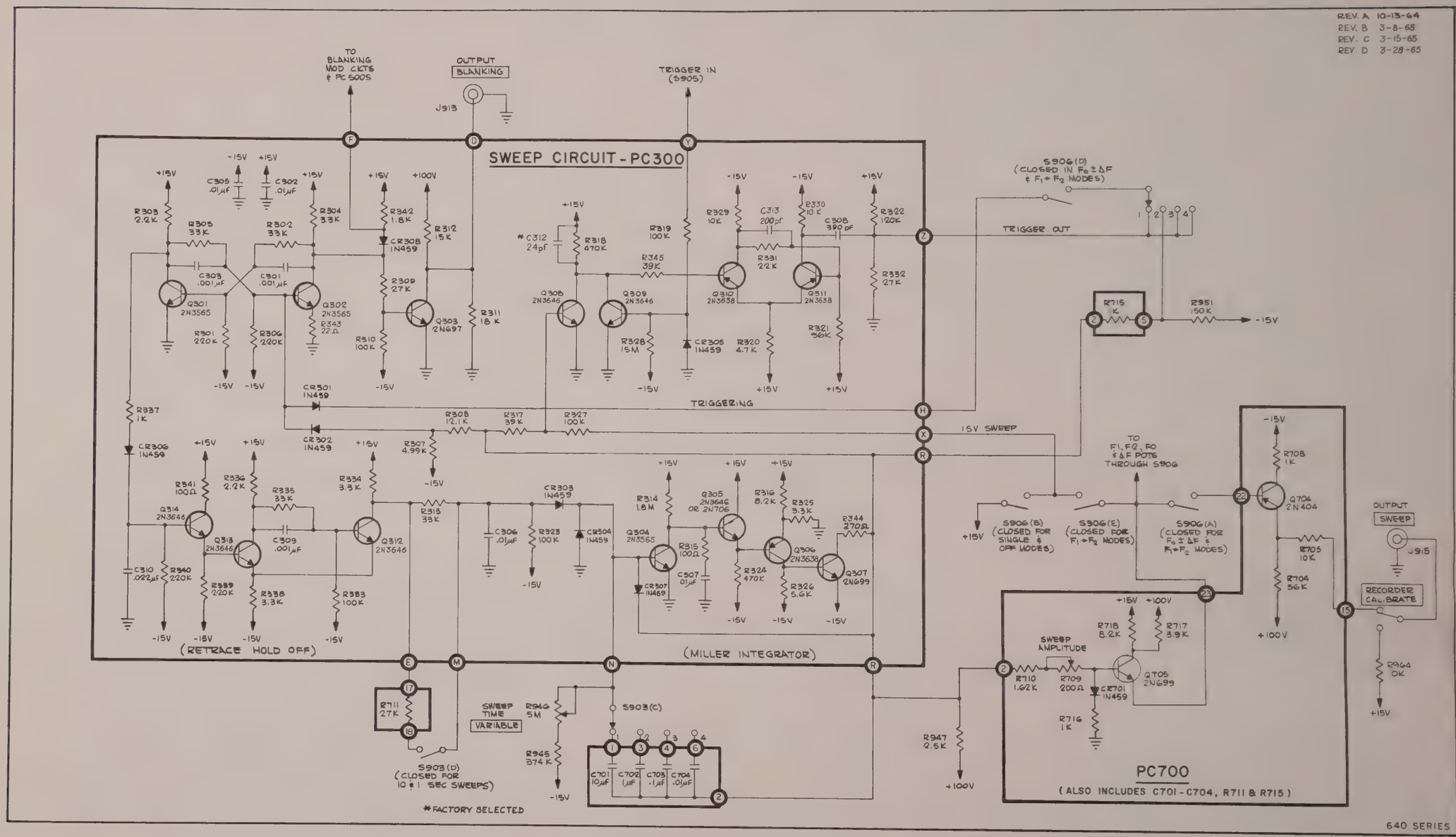
+100,—50 VOLT SUPPLIES
FIGURE 3-4



CATHODE SUPPLY
FIGURE 3-5

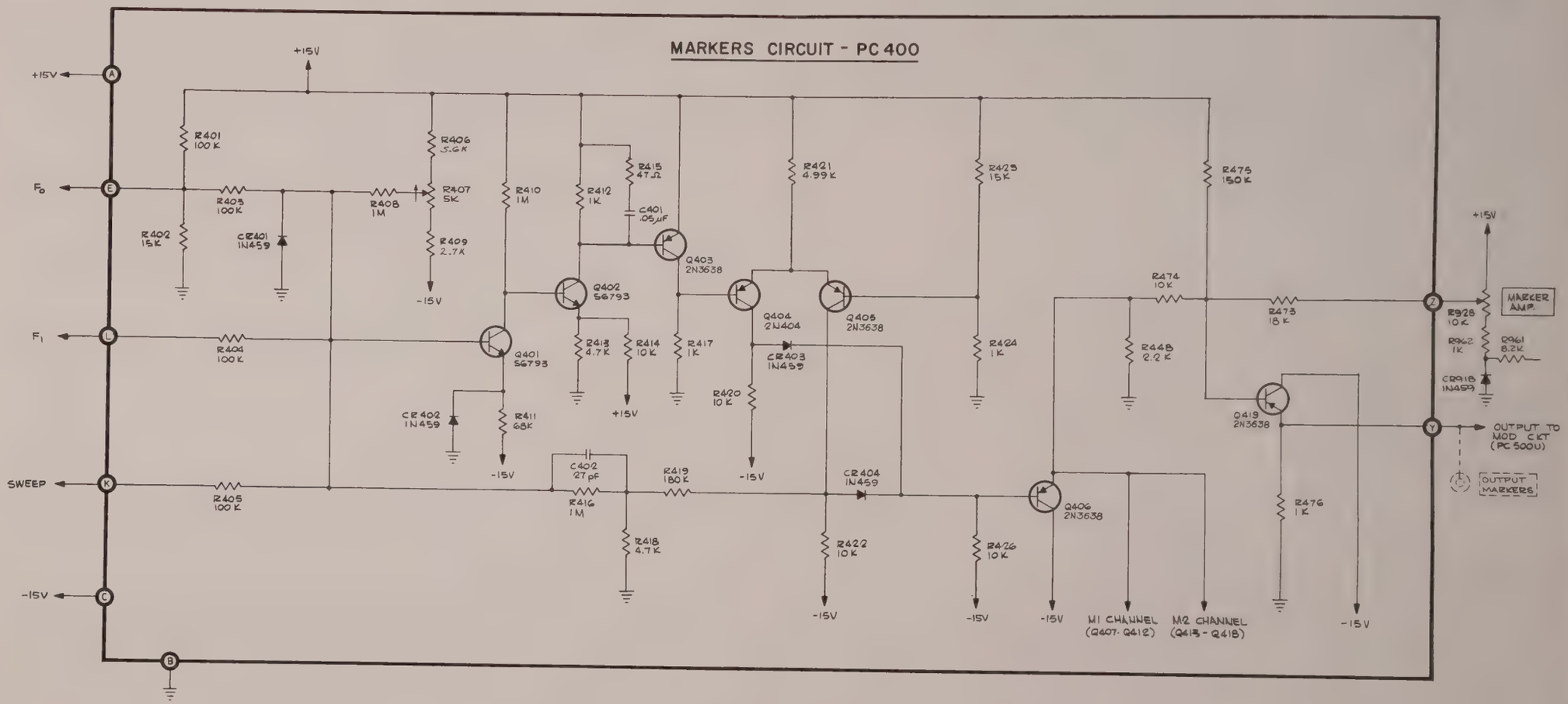


ANODE, GRID & FILAMENT SUPPLIES
FIGURE 3 - 6



SWEEP CIRCUIT
FIGURE 3-7

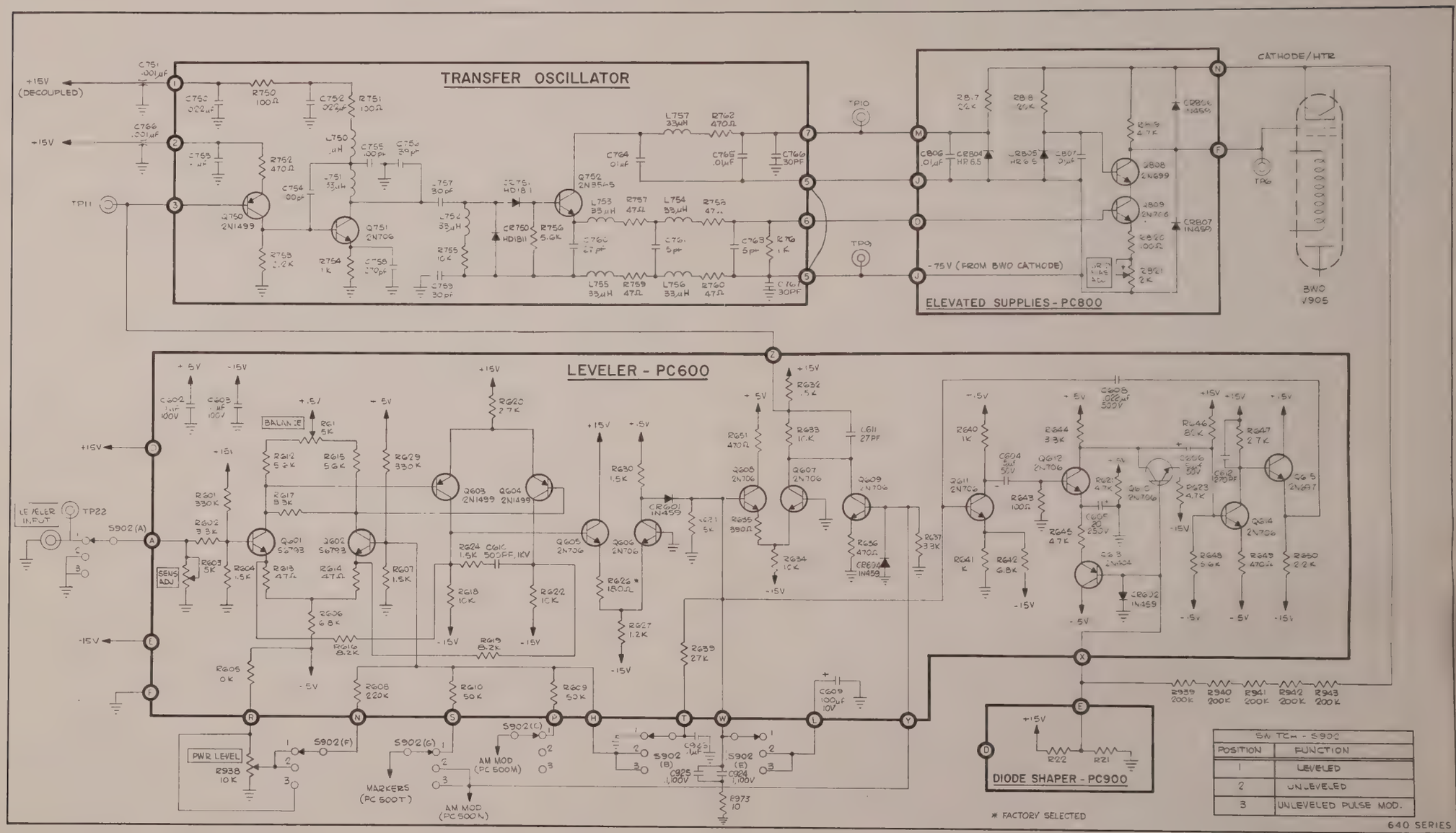
REV. A 10-15-64
REV. B 3-8-64
REV. C 3-28-64



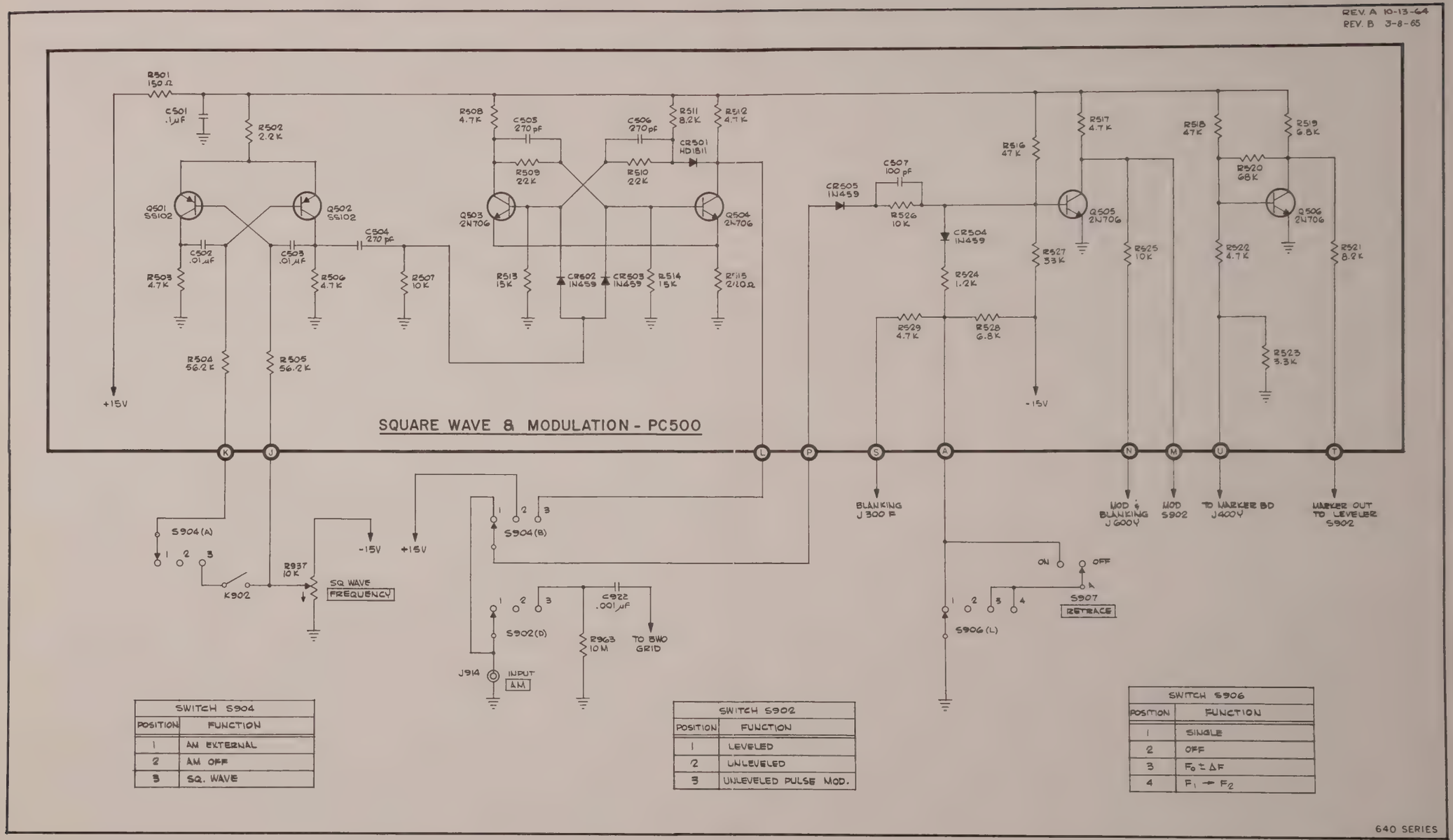
NOTE:
ONLY Fo CHANNEL IS SHOWN

640 SERIES

MARKERS CIRCUIT
FIGURE 3-8



TRANSFER OSCILLATOR AND LEVELER CIRCUIT FIGURE 3-9



SWITCH S904	
POSITION	FUNCTION
1	AM EXTERNAL
2	AM OFF
3	SQ. WAVE

SWITCH S902	
POSITION	FUNCTION
1	LEVELED
2	UNLEVELED
3	UNLEVELED PULSE MOD.

SWITCH S906	
POSITION	FUNCTION
1	SINGLE
2	OFF
3	$F_0 \pm \Delta F$
4	$F_1 \rightarrow F_2$

SQUARE WAVE & MODULATION CIRCUIT FIGURE 3-10

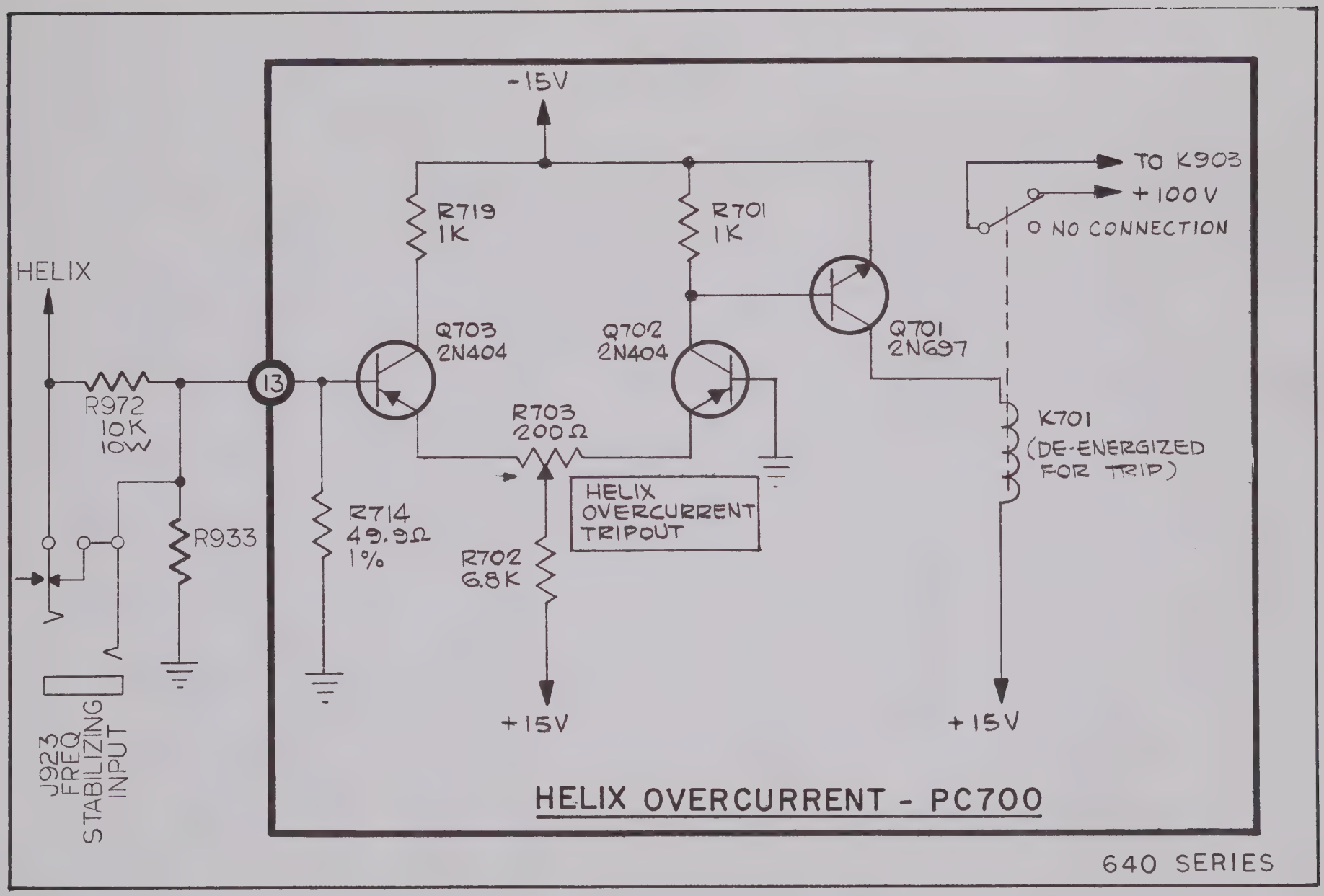
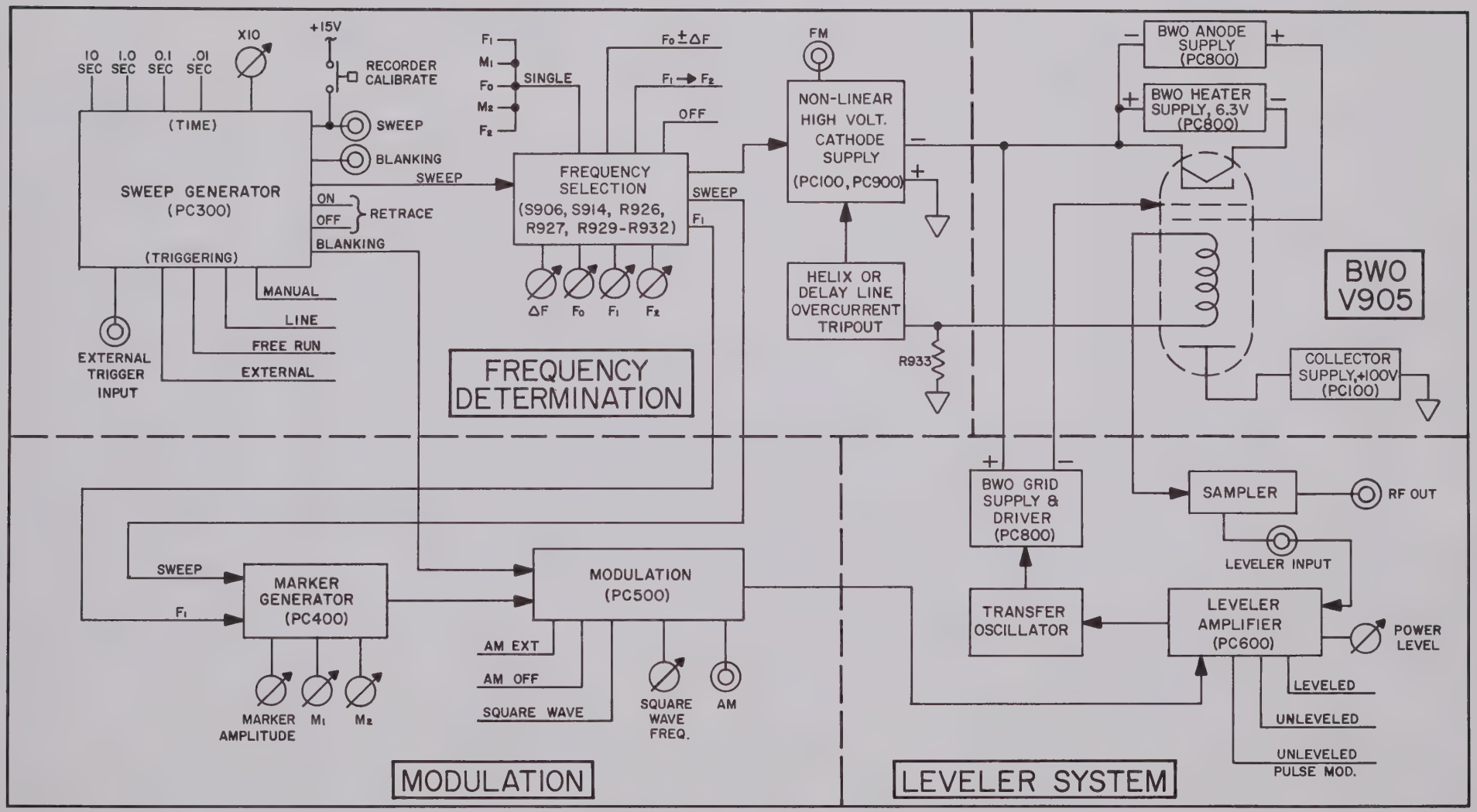

-15V
R719
1K
R701
1K
TO K903
+100V
NO CONNECTION
HELIX
Q703
2N404
Q702
2N404
Q701
2N697
13
R972
10K
10W
R703
200Ω
K701
(DE-ENERGIZED
FOR TRIP)
HELIX
OVERCURRENT
TRIPOUT
R714
49.9Ω
1%
R933
R702
6.8K
+15V
+15V
J923
FREQ
STABILIZING
INPUT
HELIX OVERCURRENT - PC700
640 SERIES

FIGURE 3-11



MODEL 640 SWEEP OSCILLATOR
BLOCK DIAGRAM
FIGURE 3-12

CAUTION: High voltages exist in this instrument. Observe caution when calibrating or performing maintenance on the instrument. When the back or top cover plates are removed, the high voltage interlock turns the HIGH VOLTAGE OFF.

4.1 TROUBLE SHOOTING

NOTE: Before attempting to trouble shoot the instrument, be certain that an apparent trouble is actually due to a malfunction within the instrument and not to improper control settings or external causes.

4.1.1 GENERAL

1. Check all fuses. Replace with type 3AB, 250 volt and current value specified.

2. If power can be applied without blowing fuse, check the four low voltage power supplies; +15, -15, +100 and -50 and the elevated supplies; the anode, grid and filament.

   NOTE: A floating voltmeter must be used to check the elevated supplies.

3. If a power supply is at fault, the cause may be due to a defective transistor or tube or one of the circuits using the supply may be excessively loading it due to a defective or grounded component.

4.1.2 NO HIGH VOLTAGE WITH HIGH VOLTAGE INDICATOR LIGHT OFF

1. Check to see if K901 - 9, 8 to -3, 4 closes after 60 seconds.

2. Check the thermal time delay relay. Check for 6.3 volts at XK901, -1, -6.

3. Check K902. If it does not close, check the +100 volt supply.

4. See if the jumper at TB901 -1, -2 is in place.

5. Check to see if K903 is de-energized. If not, check the HELIX TRIP-OUT circuit, as follows:

   a. Set the RF OUTPUT control to UNLEVELED.

   b. Set rear switch, S913, to HELIX/DELAY LINE.

   c. Set FREQUENCY mode selector to SINGLE; F_0.

   d. Connect a suitable voltmeter to TP18 and TP19 located in rear of instrument.

   e. Turn POWER switch to ON.

After approximately 60 seconds the high voltage should momentarily appear. Note the meter reading while the high voltage is present. If it is equal to or slightly greater than the value given in CHART #1, Section 5, the backward wave oscillator tube should be checked. If the relay trips out at a meter reading which is appreciably lower than the value indicated, then the setting of the TRIP-OUT circuit should be checked according to the procedures of the OVERCURRENT TRIP-OUT ADJUSTMENT, Paragraph 4.4.2.

4.1.3 NO HIGH VOLTAGE WITH HIGH VOLTAGE INDICATOR LIGHT ON

1. Check the output of T902. CAUTION: HIGH VOLTAGE, 1100 volts rms at terminals 7 and 9.

2. Check the rectifier (CR908) and the filter circuit.

3. Check series tubes V901, V902 and V903.

4. Trouble shoot the cathode supply board, J900.

4.1.4 NO RF UNDER ANY CONDITION

1. With the HIGH VOLTAGE OFF, check the backward wave oscillator heater voltage between +TP7 and -TP8. Value should be approximately 6.3 volts. If not, try to adjust to 6.3 volts by using R804 (see Figure 4-4).

   If value cannot be obtained, trouble shoot the filament supply on PC Board 800.

2. With the POWER OFF, disconnect P920 from J920. Measure the resistance at pins C and B of P920. The value should be less than 20 ohms. The specific value will depend upon the tube. If the circuit shows open, the filament of the backward wave oscillator tube is open and the tube should be replaced. If the filament is not open, reconnect P920 and J920.

3. With the POWER and HIGH VOLTAGE ON, the MODULATION control at AM OFF; the FREQUENCY mode selector at SINGLE; F_0, the RF OUTPUT control at UNLEVELED and the F_0 FREQUENCY control at 0 on the logging scale, measure the cathode voltage between (+) TP0 and (-) TP7. Compare with the tube data sheet in the envelope in back of the manual. Move F_0 FREQUENCY control to 100 on the logging scale. Again check with sheet. If values do not check out, trouble shoot high voltage supply.

4. With the HIGH VOLTAGE ON, measure the anode voltage between (+) TP5 and (-) TP7. (CAUTION: HIGH VOLTAGE.) The value should be approximately the value indicated on the tube data sheet located in the envelope. If not, try to adjust to correct value by using the ANODE ADJUST R828. (See Figure 4-4.)

CAUTION: Do not advance the ANODE ADJUST beyond the point where collector or helix current is greater than the value specified by the tube manufacturer. See envelope in back of manual.

5. Measure the voltage between (+) TP2 and (-) TP11. The value should be approximately 1/4 volt with the RF OUTPUT control full on. If not, trouble shoot the modulation circuit (PC 500) and the switching in the modulation circuit (located behind the front panel).

6. Measure the voltage between (-) TP9 and (+) TP10 (CAUTION: HIGH VOLTAGE). The value should be approximately 15 volts. Measure the voltage between (+) TP7 and (-) TP9. The value should be approximately 70 volts. If these voltages do not check out, trouble shoot the GRID supply.

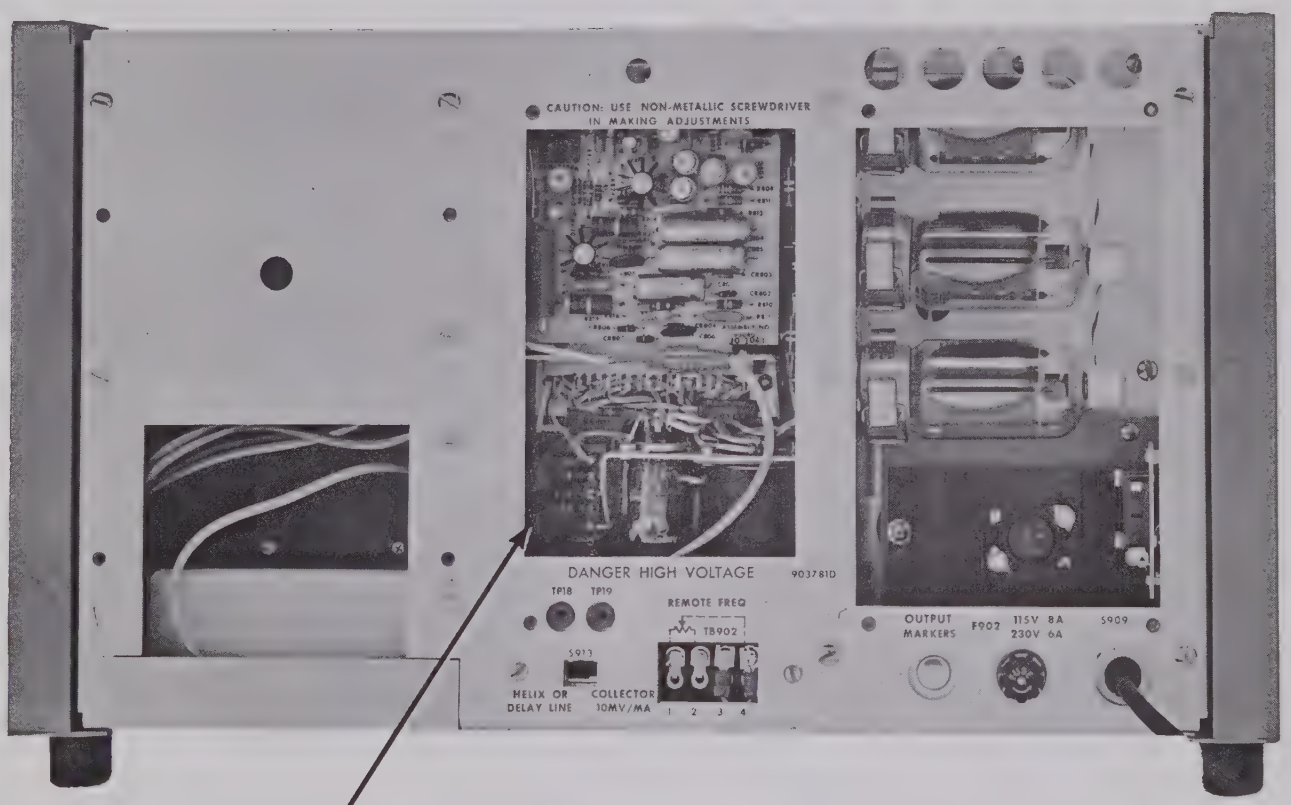
   With the RF OUTPUT control at UNLEVELED, the FREQUENCY mode selector at SINGLE; F_0 and the MODULATION control at AM OFF, measure the grid voltage between (+) TP7 and (-) TP6. The value should be less than two volts. If not, check the grid driver stage and the transfer oscillator on PC Board 800 (Elevated Supply).

7. If all power supplies and voltages check out and there is no indication of helix or collector current on the meter, replace the backward wave oscillator tube, V905.

4.1.5 RF NOT LEVELED OR NO RF OUTPUT WHEN RF OUTPUT CONTROL IS IN LEVELED POSITION

NOTE: When the RF OUTPUT control is in the LEVELED position and the power of the unit varies less than the specified value for your instrument (see Specifications, Page 1-1) as indicated on a suitable power meter over the full frequency range, the rf is LEVELED. If the power varies more than the specified value, perform the following:

1. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.



J920 & P920 – CONNECTOR (6 PIN)

REAR VIEW

FIGURE 4-1

2. SWEEP TIME to .01 seconds, calibrated.

3. SWEEP TRIGGER to LINE.

4. RETRACE control to OFF.

5. POWER LEVEL control full clockwise.

Connect the horizontal input of a suitable oscilloscope to the SWEEP OUTPUT jack of the unit. Adjust the horizontal input to give a full trace on the scope. Connect the vertical input to TP22, located on the back of the front panel. Adjust backward wave oscillator grid voltage per Paragraph 4.4.4.

Set RF OUTPUT control to UNLEVELED. Check to see if there is output across the entire frequency range.

Switch RF OUTPUT control to LEVELED. The output should decrease from UNLEVELED level across the entire frequency range and the output should be approximately 75 to 100 millivolts. If not, try to make the following adjustment: Turn BALANCE potentiometer (R611) (see Figure 4-3), full counterclockwise. Then adjust XTAL SENS potentiometer (R603) for approximately 100 millivolts at the minimum power point in frequency range (this point is usually at the low end). Adjust R611 until output over entire frequency range is approximately 100 millivolts. If this can be done, the unit will be leveled. If not, trouble shoot the leveler amplifier, grid driver and transfer oscillator circuitry.

The transfer oscillator and grid driver can be spot checked by performing the following:

FREQUENCY mode selector to SINGLE; F_0.

RF OUTPUT control to UNLEVELED.

POWER LEVEL control full clockwise.

Connect a voltmeter to (+) TP7 and (-) TP6.

The voltage should be approximately 0 volts.

Switch FREQUENCY mode selector to OFF.

The voltage should now be approximately the value of the GRID VOLTAGE CUTOFF given on Addendum Sheet A in envelope in rear of manual.

4.1.6 UNIT UNABLE TO SWEEP

1. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.

2. Set SWEEP; TIME control to .01 seconds, calibrated.

3. Set SWEEP; TRIGGER control to FREE RUN.

4. Check diodes and transistors on PC Board 300.

5. Check the waveforms and compare to those of Figure 4-2.

4.2 TEST POINTS

See Figures 4-3 and 4-4.

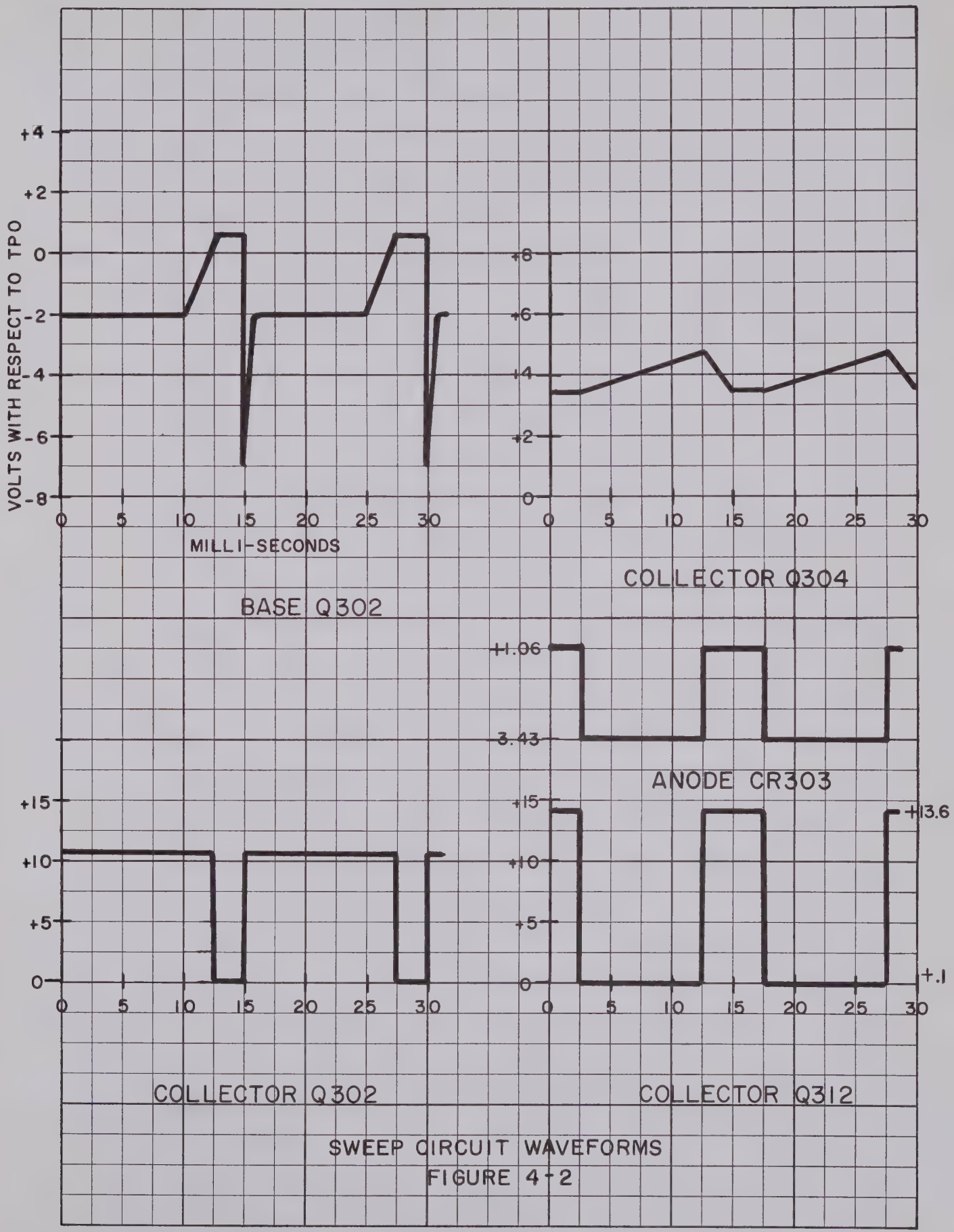
NOTE: TP0 through TP4 located left side of instrument. TP5 through TP10 located top rear insulated board.

TP0 chassis ground.

TP0 to TP1, +100 volts (low voltage supply; 97 volts to 103 volts).

TP0 to TP2, +15 volts (low voltage supply; +15 volts).

TP0 to TP3, -15 volts (low voltage supply; 14.9 volts to 15.1 volts).



SWEEP CIRCUIT WAVEFORMS
FIGURE 4-2

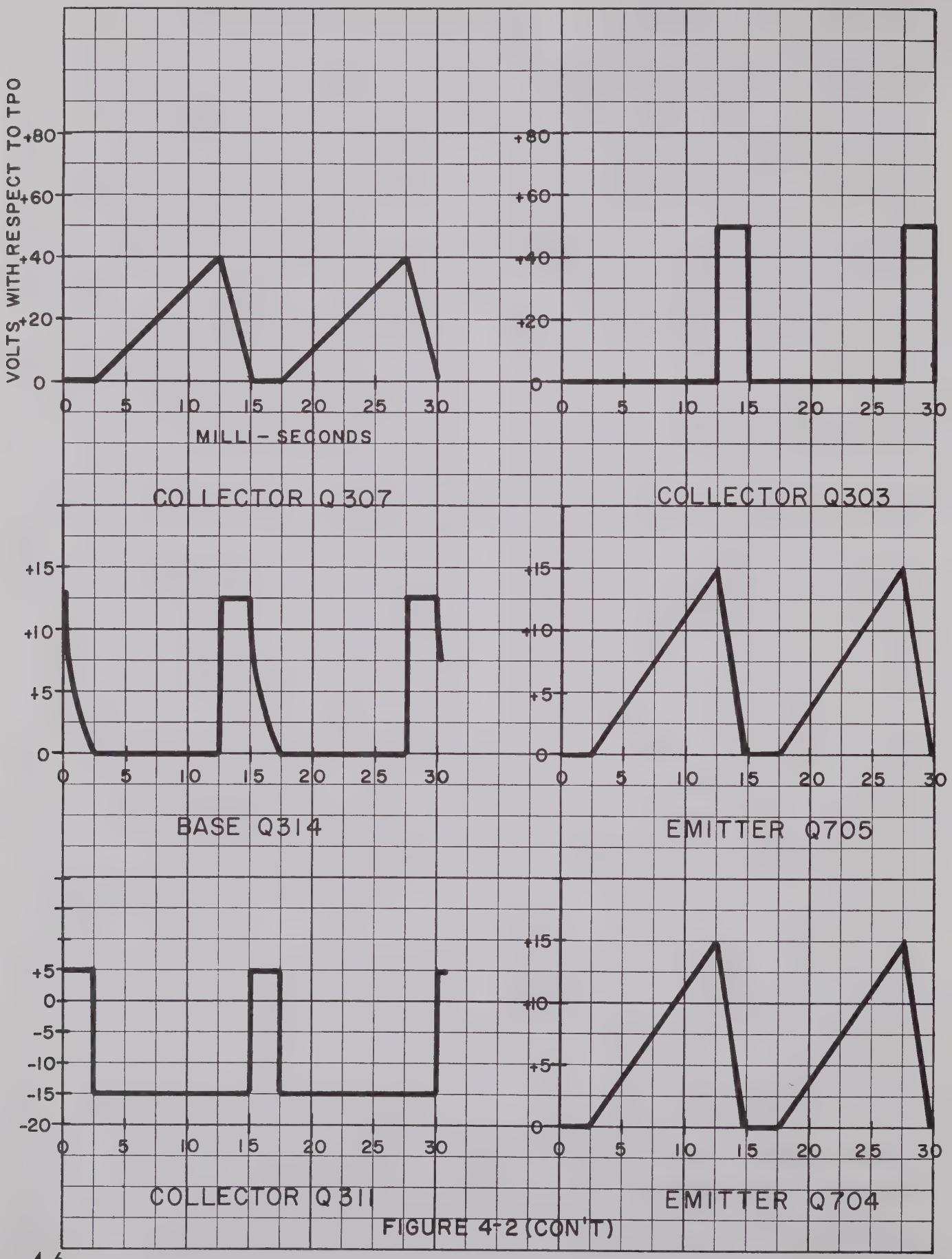


FIGURE 4-2 (CON'T)

TP0 to TP4, -50 volts (low voltage supply; 45 volts to 55 volts).

TP7 to TP5, backward wave oscillator anode voltage (see envelope - Addendum A - for value).

TP7 to TP6, backward wave oscillator grid. (See envelope - Addendum A - for value.)

TP7 to TP9, backward wave oscillator grid supply (-70 volts to -75 volts).

TP0 to TP7, backward wave oscillator cathode.

TP7 to TP8, backward wave oscillator heater (6.2 volts to 6.4 volts).

TP10 to TP9, supply for transfer oscillator (approximately 15 volts).

TP2 to TP11, input to transfer oscillator (approximately 1/4 volt). TP11 located on main chassis near C903.

TP22, output of sampler (TP22 located on back of front panel).

4.3 CALIBRATION

4.3.1 FREQUENCY CALIBRATION

1. Turn POWER switch to ON with an appropriate rf wavemeter, crystal detector and oscilloscope connected to the RF OUTPUT of the unit.
2. Set RF OUTPUT control to LEVELED.
3. Set FREQUENCY mode selector to SWEEP; $F_0 \pm \Delta F$.
4. Set F_0 FREQUENCY indicator to the lowest frequency value of the instrument (0 on the logging scale).
5. Set the rf wavemeter to this frequency.
6. Adjust R125 (START FREQUENCY ADJUST) so the wavemeter pip appears in the center of the oscilloscope face. See Figure 4-3.

   NOTE: ΔF AMPLITUDE control should be full on (clockwise).
7. Reduce the ΔF AMPLITUDE control while adjusting R125 so the pip remains in the center.
8. Move F_0 FREQUENCY indicator to the high frequency value of the instrument (100 on logging scale).
9. Set the rf wavemeter to this frequency.
10. Adjust R121 (END FREQUENCY ADJUST) so the wavemeter pip appears in the center of scope face.

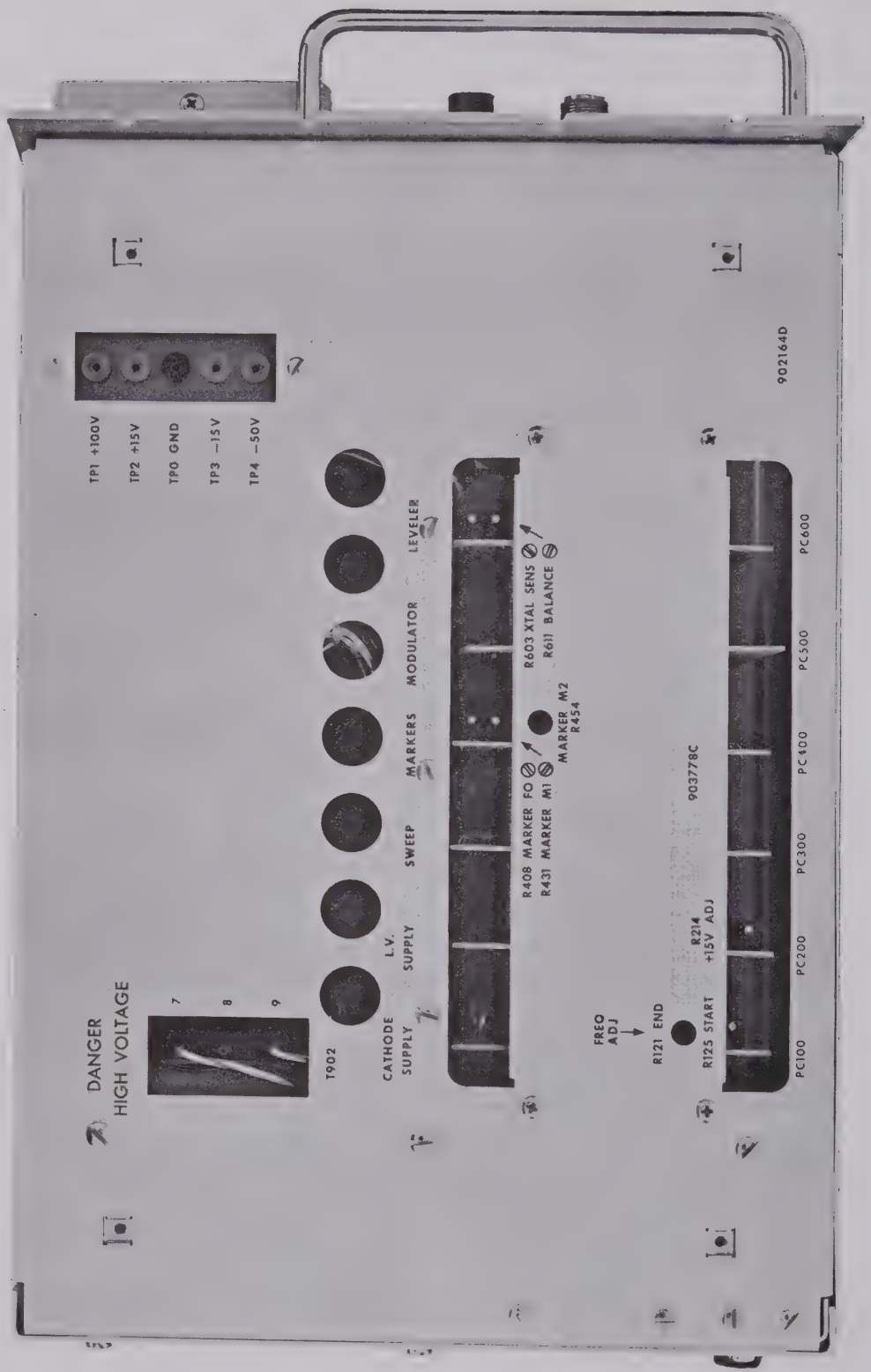
    NOTE: ΔF AMPLITUDE control should be full on (clockwise).
11. Reduce the ΔF AMPLITUDE control while adjusting R121 so the pip remains in the center of the oscilloscope face.

Repeat Steps 1 through 11 until both ends are on frequency. Repeating the steps is necessary because of the interaction of R125 and R121.

4.3.2 WIDE SWEEP CALIBRATION

See Figure 4-4.

1. FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.
2. F_1 FREQUENCY control to 0 on logging scale.
3. F_2 FREQUENCY control to 100 on logging scale.
4. Adjust frequency meter to frequency of F_2 setting.



LEFT SIDE VIEW

FIGURE 4-3

4. Adjust R709 until pip is exactly at end of sweep as seen on the oscilloscope.

4.3.3 MARKER CALIBRATION

1. Set RF OUTPUT control to LEVELED.

2. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.

3. Set F_1 FREQUENCY control to 0 on the logging scale.

4. Set F_2 FREQUENCY control to 10 on the logging scale.

5. Set SWEEP; TIME to .1 second (calibrated).

6. Set SWEEP; TRIGGER to LINE.

7. Turn MARKER AMPLITUDE up as necessary.

8. Apply the sweep output of the unit to the horizontal deflection input of an oscilloscope.

9. With a suitable frequency meter and crystal detector in series with the output, display the output of the crystal detector on the oscilloscope.

10. Set the M_1 MARKER control to any frequency between 0 and 10 on the logging scale.

11. Set the frequency meter to this frequency.

12. Adjust R432 (MARKER M_1) until the wavemeter pip and the marker pip coincide.

13. Remove M_1 marker pip from the oscilloscope and set the M_2 MARKER control to the frequency of the frequency meter.

14. Adjust R455 (MARKER M_2) until the wavemeter pip and the marker pip coincide.

15. Remove M_2 marker pip from the oscilloscope and set F_0 FREQUENCY control to the frequency of the frequency meter.

16. Adjust R407 (MARKER F_0) until the two pips coincide.

4.4 INTERNAL ADJUSTMENTS

NOTE: Both the top and rear cover plates actuate safety interlock switches that prevent high voltage operation when removed.

4.4.1 +15 VOLT ADJUSTMENT

See Figure 4-3.

1. Remove the left handle side cover plate.

2. Connect a 0.1% dc voltmeter between TP2 and TP0.

3. Adjust R214 (+15 VOLT ADJUST) for 15.00 volts.

4. This adjustment also affects the -15 volt, +100 and -50 volt supplies, but the absolute value of these supplies is not critical.

5. Replace the left handle side cover plate.

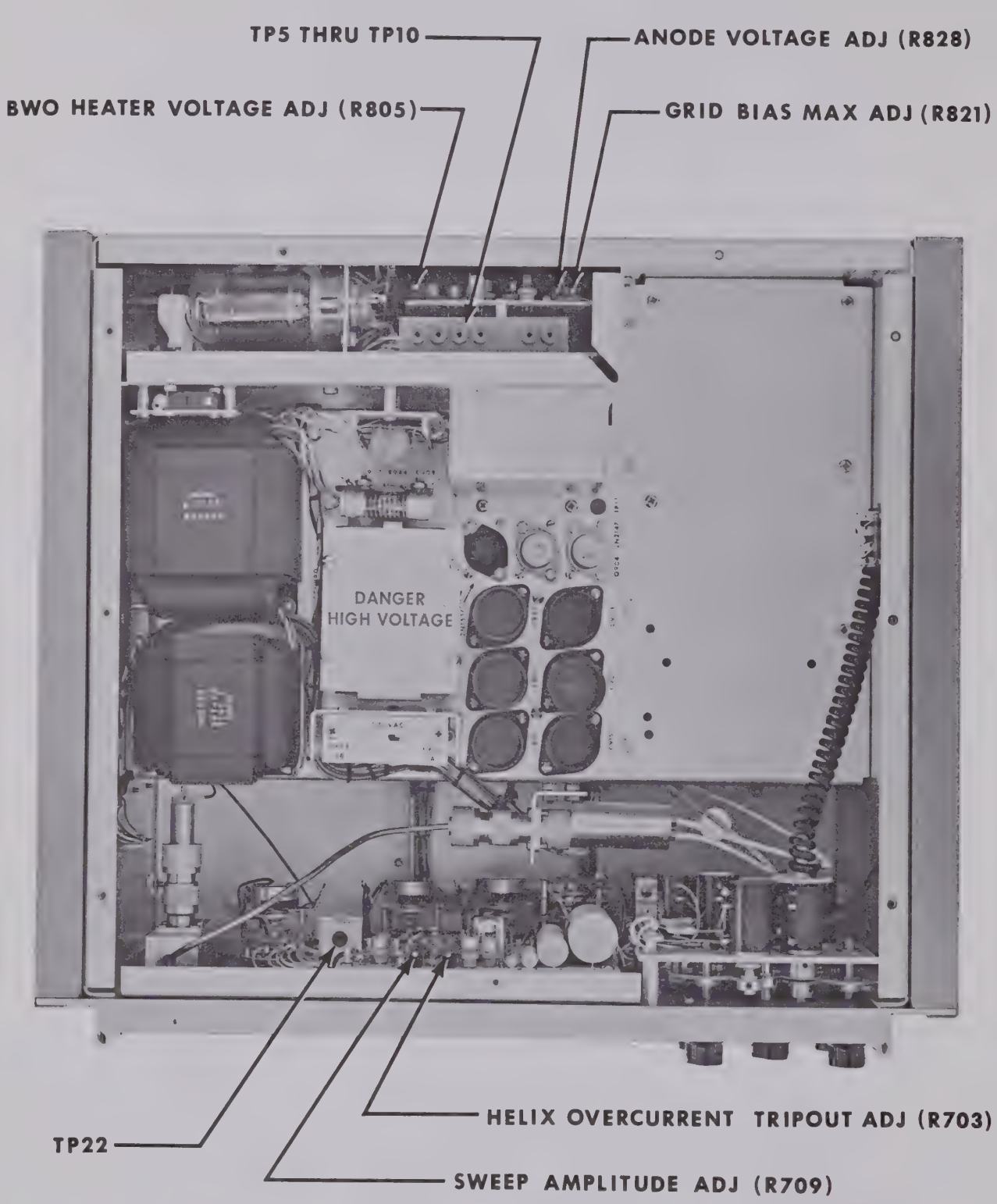
4.4.2 OVERCURRENT RELAY TRIP-OUT ADJUSTMENT

See Figure 4-4.

Check Chart #1, Section 5, for proper setting and full scale reading of CURRENT TRIP-OUT value when switch S913 is in HELIX/DELAY LINE setting.

1. Remove the top cover.

2. Connect a 3 K ohm resistor, a 20 K or greater potentiometer and a suitable current meter



TOP VIEW

FIGURE 4-4

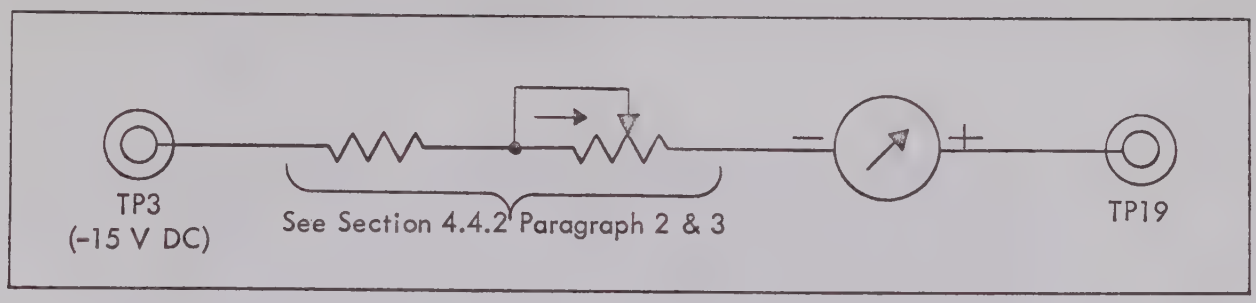


Figure 4-5

(5 ma) between TP3 (-15 v dc) and TP19. This set up is for a full scale deflection of 5 ma.

3. For a full scale deflection of 50 ma, connect a 270 ohm resistor, a 5 K ohm or greater potentiometer and a suitable current meter (50 ma) between TP3 (-15 v dc) and TP19.

   See Figure 4-5.

4. Turn POWER switch to ON but leave the HIGH VOLTAGE off by leaving the high voltage interlock open.

5. Set rear switch, S913, to HELIX/DELAY LINE.

6. Adjust the potentiometer by starting at a low value of current and gradually increase until the overcurrent relay, K701, trips (de-energizes). Check current at which relay tripped. Adjust R703 so the relay trips at the current value indicated in Chart #1.

   NOTE: Always proceed from a low current value by adjusting the potentiometer each time the trip-out point is checked.

4.4.3 BACKWARD WAVE OSCILLATOR HEATER ADJUSTMENT

See Figure 4-4.

1. Remove the top cover plate.
2. Turn POWER switch to ON but leave the HIGH VOLTAGE off by leaving the high voltage interlock open.
3. Set FREQUENCY mode selector to OFF.
4. Set F_0 FREQUENCY indicator to 0 on logging scale.
5. Set MODULATION control to AM OFF.
6. Set SWEEP; TRIGGER to FREE RUN.
7. Set SWEEP; TIME to .01 seconds.
8. Connect the positive lead of a dc voltmeter to TP7 and the negative lead to TP8.
9. With the instrument ON and the backward wave oscillator connected, adjust R805 to 6.3 volts dc. (This should be done at 115 volt line.)
10. Replace top cover plate.

4.4.4 BACKWARD WAVE OSCILLATOR GRID ADJUSTMENT

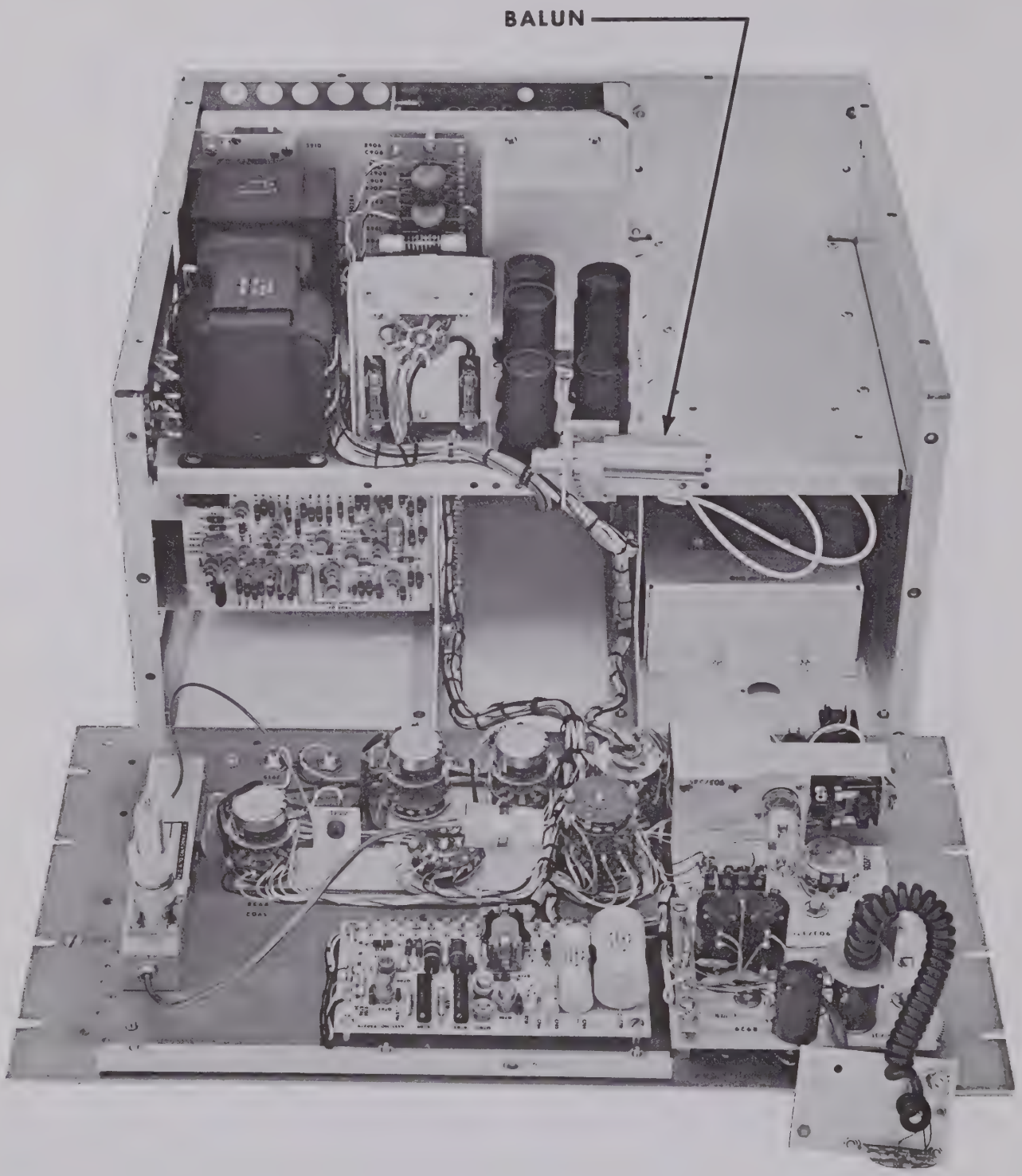
See Figure 4-4.

Remove the rear cover plate. Turn POWER switch to ON.

1. RF OUTPUT control to UNLEVELED.
2. FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.
3. MODULATION control to SQUARE WAVE.
4. RETRACE control to OFF.
5. Adjust the GRID BIAS MAX. ADJUST (R821) so that the backward wave oscillator tube does not generate any rf during retrace and during the portion of the square wave where rf is off.

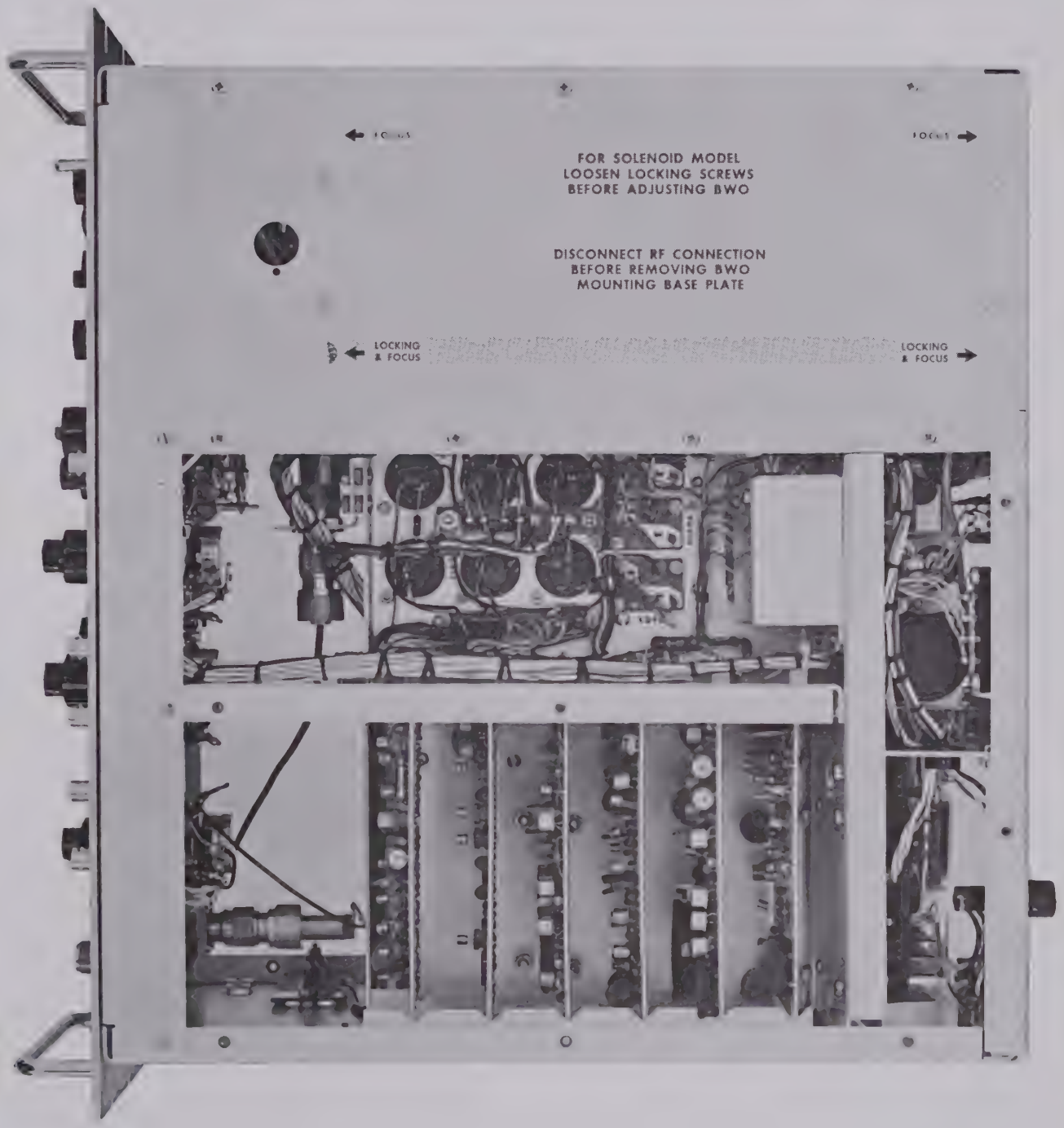
4.5 FRONT PANEL

The front panel may be dropped forward for access to components mounted inside. Remove the five control knobs and the dial mechanism cover. Remove the top cover plate and the right and left handle sides. Remove the coiled cable bracket (two screws). Remove any rf connections using caution. Remove the screws from the periphery of the front panel. The panel may now be turned



FRONT VIEW (PANEL OPENED)

FIGURE 4-6



BOTTOM VIEW

FIGURE 4-7

forward on its face as all wiring comes out the bottom of the panel.

4.6 BACKWARD WAVE OSCILLATOR TUBE REPLACEMENT

See Figure 4-7.

To replace the backward wave oscillator tube, remove the top cover plate.

1. Disconnect the rf connection from the tube to the unit.

   NOTE: On units with baluns, disconnect the balun bracket from the unit before disconnecting the rf connector. Remove the balun from its bracket prior to Step 2. See Figure 4-6.

2. Turn unit over and remove the bottom cover plate.

3. Disconnect the one and six pin connector (P921 and P920).

   NOTE: Some units have only the six pin connector (P920).

4. Remove the seven Phillips head screws from the periphery of the backward wave oscillator mounting base plate. See Figure 4-7.

5. Lift the whole tube assembly (tube and base plate) from the unit by using the finger hole provided.

6. Disconnect the tube from its base plates. Note position and screw hole alignment of old tube to aid in positioning of new tube.

7. Reverse procedure for installation.

4.7 FREQUENCY AND MARKER POTENTIOMETER REPLACEMENT

NOTE: The F_1 and F_2 potentiometers can be removed without dropping the front panel.

A. REPLACEMENT OF F_1 POTENTIOMETER

1. Remove top cover.

2. Unsolder leads from potentiometer terminals.

3. Rotate F_1 control knob full counterclockwise (CCW) to its lower mechanical stop. It is important to remember the exact position of the indicator when the stop is reached, as this position must be maintained when the new potentiometer is installed.

4. Loosen both potentiometer shaft gear hub set screws.

CAUTION: Do not disrupt relative position of the F_2 potentiometer shaft gears. Make a pencil mark on the mounting plate and gear and realign before meshing the F_1 gear. If the F_2 gears are moved and not realigned, the mechanical stops will not be oriented and realignment must be performed according to the procedures of Section B, starting with Step 8.

5. Slide gear forward.

6. Remove potentiometer retaining nut and washer. While holding nut, washer and gear, withdraw potentiometer from mounting plate, noting orientation of potentiometer terminals.

7. Insert new potentiometer engaging washer, nut and gear. Tighten retaining nut, remembering orientation of potentiometer terminals.

8. Position the F_1 potentiometer shaft full clockwise (CW) as viewed from the shaft end. This can best be accomplished by lightly tightening one gear set screw and while the gear is disengaged, finger turning the shaft full clockwise. Loosen the set screw.

9. Before engaging the gear, check to see if the dial indicator is in the exact position as it was before and check to see if the F_2 gear lines up with its pencil mark.

10. Engage the F_1 potentiometer shaft gear and tighten both screws. NOTE: If the indicator is not in the exact position as noted in Step 3, do not position it by turning the F_1 dial cord drum. Instead, disengage the gear and reposition the indicator.

B. REPLACEMENT OF F_2 POTENTIOMETER

1. Remove the top cover, the five control knobs, and the dial mechanism cover.

2. Unsolder the three leads from the potentiometer terminals. Remove the three small screws which hold the coiled wire bracket to the back of the potentiometer. The coiled wire is now free.

3. Rotate F_1 knob full counterclockwise (CCW) and the F_2 knob full clockwise (CW).

4. Loosen F_2 potentiometer gear hub set screws on both gear hubs.

5. Remove F_2 potentiometer by turning the potentiometer case in a clockwise direction as viewed from the shaft end.

6. Insert new potentiometer and tighten by turning in a counterclockwise direction.

7. Tighten set screws on gear hub closest to the mounting plate.

8. Disengage the idler gear connecting the F_1 potentiometer shaft gear to the F_2 potentiometer body gear.

9. Set the upper mechanical stop. This stop can be seen as a bent tooth on the gear on the F_2 potentiometer shaft and a small extension on the F_2 dial indicator shaft gear. The stop must be set below the center line of the F_2 dial indicator gear and the F_2 potentiometer gear as the F_2 knob turns clockwise.

   It may take a few attempts but no difficulty should be encountered.

10. Tighten the potentiometer shaft gear set screws.

11. Rotate the F_2 knob counterclockwise until the F_2 indicator is approximately 1/64" from the F_1 indicator. Now, while holding the F_2 knob so as to maintain the 1/64" distance, rotate the entire F_2 potentiometer counterclockwise (CCW) until the mechanical stop is felt. If the indicators touch because the F_2 knob was allowed to turn after the stop was reached, a slight clockwise turn on the F_2 knob will separate them.

12. Very carefully engage the idler gear between the F_1 potentiometer shaft gear and the F_2 potentiometer body gear (the one closest to the mounting plate) and tighten set screws.

    The lower and upper mechanical stops are now set. A gap should be maintained between indicators over the entire distance of the dial. Adjustments should be made beginning with Step 8 if gap is not maintained.

13. After the stops have been set, run the F_2 indicator full clockwise (CW) and the F_1 indicator to approximately 50 on the logging scale.

14. Remove the three screws from the back of the F_2 potentiometer.

CAUTION: Do not let the back of the potentiometer come off.

15. Secure the coiled wire bracket to the back of the potentiometer, and solder the three leads to the potentiometer terminals.

C. REPLACEMENT OF M_2 POTENTIOMETER

NOTE: Removal of the M_1, M_2 or F_0 potentiometer requires dropping the front panel forward.

Remove the top cover, the right and left handle sides, the five control knobs and the dial mechanism cover. Remove the screws from the periphery of the front panel. Remove the screws which hold the coiled cable to the side of the instrument. Remove any applicable rf connections. Drop front panel forward.

1. Unsolder the wires to potentiometer terminals.
2. Turn the M_1 and M_2 knobs full counterclockwise (CCW).
3. Remove retaining ring and thrust washer from the M_2 knob shaft.
4. Loosen the two set screws on the M_2 knob shaft gear hub.
5. Loosen the M_2 dial cord hub and press M_2 knob shaft about halfway out.
6. Loosen potentiometer shaft gear hub set screws.
7. Remove potentiometer retaining nut and washer and remove M_2 potentiometer remembering orientation of potentiometer terminals.
8. Position idler gear (with planetary gear) and new potentiometer shaft full clockwise (CW) as viewed from the front panel.
9. Insert new potentiometer and tighten retaining nut remembering potentiometer orientation.
10. Engage potentiometer shaft gear and tighten set screws. Make sure the potentiometer shaft is full clockwise (CW).
11. Press M_2 knob shaft into place and replace thrust washer and retaining ring.
12. Engage M_2 knob shaft gear with idler gear and potentiometer shaft gear.
13. Tighten set screws on M_2 knob shaft gear.
14. Rotate M_2 knob fully counterclockwise (CCW).
15. Rotate M_2 dial cord CCW until dial indicators are approximately 1/64" apart.
16. Tighten M_2 dial cord drum set screw.

D. REPLACEMENT OF THE M_1 POTENTIOMETER

1. Remove the Helix Overcurrent PC Board assembly. This will permit a wrench to be inserted from the left side of the gear assembly as viewed from the front of the unit.
2. Position M_1 and M_2 control knobs full CCW. Note position of indicators.
3. Loosen the M_1 potentiometer shaft gear hub set screws.
4. Remove M_1 potentiometer retaining nut and withdraw M_1 potentiometer, remembering orientation of potentiometer terminals.
5. Insert new potentiometer. Tighten retaining nut.
6. Replace M_1 potentiometer shaft gear making sure that the M_1 indicator is in previous position and the M_1 potentiometer shaft is full clockwise (CW).
7. Tighten set screws on potentiometer shaft gear.

8. Replace Helix Overcurrent PC Board.

9. Resolder leads.

E. REPLACEMENT OF THE F_0 POTENTIOMETER

1. Rotate the F_1 , F_0 and F_2 control knobs full counterclockwise (CCW).

2. Unsolder the leads to the F_0 potentiometer terminals.

3. Remove the F_1 knob shaft retaining ring and thrust washer.

4. Loosen the F_1 dial cord drum set screws, remembering the exact position of F_1 indicator.

5. Move F_1 knob shaft forward disengaging F_1 knob shaft gear. Loosen F_1 knob shaft gear hub set screws.

6. Slide F_1 knob shaft forward until inner locking ring bottoms on F_1 knob shaft gear.

7. Loosen set screws on F_0 potentiometer shaft gear.

8. Loosen potentiometer retaining nut.

9. Withdraw potentiometer remembering orientation of potentiometer terminals.

10. Insert new potentiometer positioning shaft full clockwise (CW) as viewed from the shaft end.

11. Tighten potentiometer retaining nut.

12. Engage F_0 potentiometer shaft gear and tighten two set screws.

13. Loosen set screw on F_0 dial cord drum and note position of indicator. Rotate F_0 knob full counterclockwise (CCW). The stop of the potentiometer should be felt.

14. Position the F_0 indicator to position as noted in Step 13.

15. Tighten F_0 dial cord drum set screw.

16. Replace F_1 knob shaft into position and replace thrust washer and retaining ring.

17. With the F_1 potentiometer shaft fully clockwise (CW), slide the F_1 knob shaft gear up and intermesh with F_1 potentiometer shaft gear. Tighten gear set screws.

18. Rotate F_1 knob shaft fully counterclockwise (CCW) and tighten F_1 dial cord drum after positioning indicator as it was before, Step 4 above.

19. Resolder leads.

4.8 BACKWARD WAVE OSCILLATOR TUBE ADJUSTMENT

1. Replace the backward wave oscillator tube per Section 4.6 of the instruction manual. Do not connect to the power supply.

2. Turn the POWER switch to ON and adjust the ANODE and GRID voltages to the value specified on the data sheet for the new tube. It may be necessary to replace resistor R831 in order to obtain correct ANODE voltage. The correct value of R831 can be determined per Chart A. Check HEATER voltage for approximately 6.6 volts at (+) TP7 and (-) TP8.

CAUTION: These voltages are referenced to the cathode which is at a high voltage with respect to ground. Use a floating voltmeter.

Chart A

BWO Anode Voltage	R831*
206 - 264	1.18 M
182 - 237	768 K
158 - 207	499 K
138 - 180	365 K
122 - 160	280 K
107 - 140	221 K
95 - 125	178 K
84 - 110	147 K
70 - 90	118 K
65 - 85	100 K
56 - 75	90 K
59 - 66	76.8 K

*1/2%, 1/2 watt, metal film.

3. Turn the POWER switch to OFF and connect the backward wave oscillator tube to the power supply (P920 to J920). Monitor the HEATER VOLTAGE.

4. Turn the POWER switch to ON. Adjust the HEATER to 6.3 volts using R805 (see Figure 4-4).

5. Connect a power meter as shown in Figure 4-8.

6. Check the unleveled power output across the entire frequency band.

CAUTION: Do not exceed the thermistor power rating.

7. If the power is below specifications at any point, increase the ANODE voltage using the ANODE ADJUST R828.

8. For leveled units, check the leveled power output and power variation across the entire frequency band.

9. If the unit does not meet the leveled output specification, make adjustments per Section 4.1.5.

10. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$,

    set SWEEP; TIME to 0.1 seconds,

    set F_1 FREQUENCY control to 0 on logging scale,

    set F_2 FREQUENCY control to 100 on logging scale,

    and METER control to RF UNLEVELED.

11. Connect an oscilloscope to the unit as shown in Figure 4-8.

12. Set RETRACE control to OFF. The rf should be off during the entire retrace period. If it is not, increase the GRID voltage using R821 (GRID BIAS MAX ADJUST) so that this condition is met.

13. Set the MODULATION control to SQUARE WAVE. The rf should be off during the off portion of the square wave over the entire frequency band. If not, increase the GRID voltage slightly using R821.

14. Connect the power meter as shown in Figure 4-8. Measure the power output and power variation across the entire band during LEVELED operation. Use slow sweep or manual control.

15. Disconnect the power meter and connect an oscilloscope as shown in Figure 4-8.

16. Set FREQUENCY mode selector to SWEEP; $F_0 \pm \Delta F$, set SWEEP; time to 0.1 seconds.

17. Set F_0 FREQUENCY indicator to 0 on logging scale, and set the frequency meter to the frequency corresponding to this setting.

18. Adjust the START FREQUENCY ADJUSTMENT (R125) so that the frequency meter marker pip is in the center of the oscilloscope face.

    NOTE: Δ F AMPLITUDE control should be full on (clockwise).

19. Reduce the Δ F AMPLITUDE control while adjusting R125 so the pip remains in the center.

20. Move F_0 FREQUENCY indicator to 100 on the logging scale and set the frequency meter to the frequency corresponding to this setting.

21. Adjust the END FREQUENCY ADJUSTMENT (R121) so that the frequency meter marker pip is in the center of the oscilloscope face.

    NOTE: Δ F AMPLITUDE control should be full on (clockwise).

22. Reduce the ΔF AMPLITUDE control while adjusting R121 so the pip remains in the center.

23. Repeat Steps 17 through 22. Repeating the steps is necessary because of the interaction of R125 and R121.

4.9 WARRANTY

All workmanship and materials except the backward wave oscillator tube are guaranteed for one year. Details covering warranty adjustments are presented on "Shipment Damage Calim" page at the end of this manual.

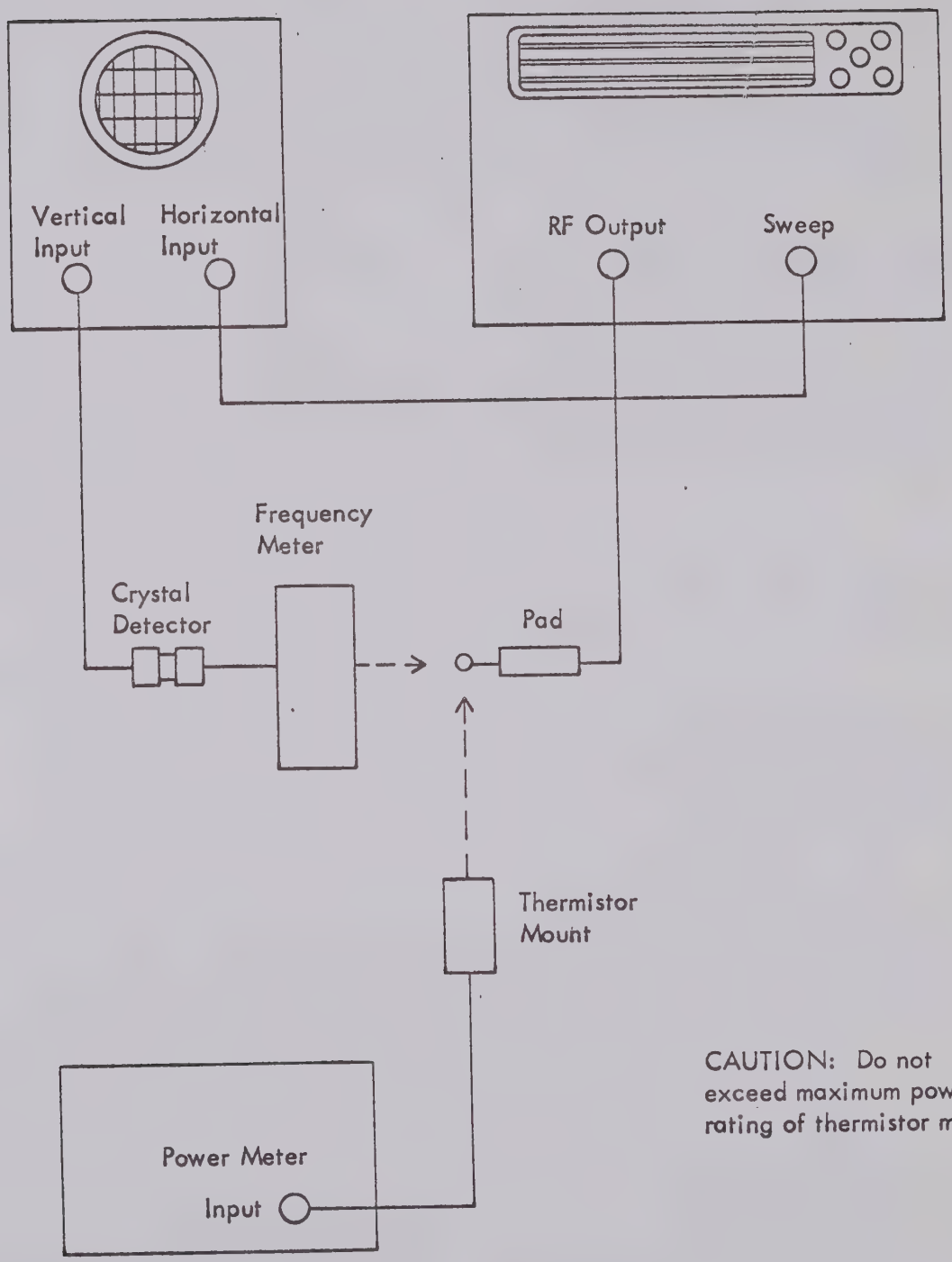

Vertical Input
Horizontal Input
RF Output
Sweep
Frequency Meter
Crystal Detector
Pad
Thermistor Mount
Power Meter
Input
CAUTION: Do not exceed maximum power rating of thermistor mount.

Figure 4-8

SECTION 5

CHARTS and GRAPHS

CHART #1
Information for Individual 640 Models

MODEL NUMBER	T902	R933	S913 HELIX/DELAY LINE (FULL SCALE)	J900 HELIX SHAPER BOARD	V905 BWO	SAMPLER (CRYSTAL CA1 & DETECTOR DT1)	CURRENT TRIP-OUT VALUE	E_1	E_2	E_3	RF CIRCUIT DIAGRAM
641B	7 & 8	12.5 Ω	5 ma	950373	SE214C	-	5 ma	-	-	-	5-1
641KB	7 & 8	12.5 Ω	5 ma	950373	SE214C	950780	5 ma	LP Filter 256-6	-	-	5-1
641B-S1	7 & 8	12.5 Ω	5 ma	950848	SE219-3	-	5 ma	-	-	-	5-1
641KB-S1	7 & 8	12.5 Ω	5 ma	950848	SE219-3	950781	5 ma	-	-	-	5-1
642B	7 & 9	12.5 Ω	5 ma	950718	SE215A-2	-	3.5 ma	-	-	-	5-1
642KB	7 & 9	12.5 Ω	5 ma	950718	SE215A-2	950852	3.5 ma	LP Filter 256-2	-	-	5-1
642B-S1	7 & 9	12.5 Ω	5 ma	950729	SE215-6	-	3.5 ma	-	-	-	5-1
642KB-S1	7 & 9	12.5 Ω	5 ma	950729	SE215-6	950908	3.5 ma	Adapter UG57B/U	-	RF Cable 950356B-1	5-1
643B	7 & 9	12.5 Ω	5 ma	950323	SE211A-8	-	3.5 ma	-	-	-	5-1
643KB	7 & 9	12.5 Ω	5 ma	950323	SE211A-8	950784	3.5 ma	LP Filter 256-3	-	RF Cable 950356B-1	5-1
643B-S1	7 & 9	12.5 Ω	5 ma	950524	SE221-1	-	3.5 ma	-	-	-	5-1
643KB-S1	7 & 9	12.5 Ω	5 ma	950524	SE221-1	950783	3.5 ma	LP Filter 256-4	-	RF Cable 950356B-1	5-1
643B-S2	7 & 9	12.5 Ω	5 ma	950857	SE211B-7	-	3.5 ma	-	-	-	5-1
643KB-S2	7 & 9	12.5 Ω	5 ma	950857	SE211B-7	950896	3.5 ma	Adapter UG57B/U	-	RF Cable 950356B-1	5-1
644B	7 & 9	12.5 Ω	5 ma	950371	SE209-1	-	3.5 ma	-	-	-	5-1
644KB	7 & 9	12.5 Ω	5 ma	950371	SE209-1	950891	3.5 ma	RF Cable 950871C-3	-	-	5-1
644E	7 & 8	1.05 Ω	50 ma	950633	VA173A	-	30 ma	RF Cable 950356B-3	-	-	5-2
644KE	7 & 8	1.05 Ω	50 ma	950633	VA173A	950891	30 ma	RF Cables 950357B-1, 950356B-2 & Filter 256-5	-	-	5-2
644E-S1	7 & 8	1.05 Ω	50 ma	950368	VA173A	-	30 ma	-	-	-	5-2
644KE-S1	7 & 8	1.05 Ω	50 ma	950368	VA173A	950891	30 ma	RF Cables 950357B-1, 950356B-2 & Filter 256-5	-	-	5-2
645B	7 & 9	12.5 Ω	5 ma	950430	SE209A-2	-	3.5 ma	-	-	Extension 950622B	5-1
645KB	7 & 9	12.5 Ω	5 ma	950430	SE209A-2	950544	3.5 ma	-	WG to Coax Adapter 253-1	Bend 950627B	5-1
645E	7 & 8	1.05 Ω	50 ma	950433	VA173E	-	30 ma	RF Cable 950871C-4 and Adapter 253-1	-	Extension 950622B	5-2
645KE	7 & 8	1.05 Ω	50 ma	950433	VA173E	950786	30 ma	RF Cable 950871C-4, Adapter 253-1, Filter 256-5	WG to Coax Adapter 253-1	Bend 950627B	5-2
646B	7 & 9	12.5 Ω	5 ma	950698	SE220A-2	-	3.5 ma	-	-	Extension 950623B	5-1
647E	7 & 8	1.05 Ω	50 ma	950330	VA162A	-	30 ma	Flexguide 254-7; Extension 950564	-	Bend 950628B	5-2
647KE	7 & 8	1.05 Ω	50 ma	950330	VA162A	950892	30 ma	Flexguide 254-7	-	Bend 950628B	5-2
648E	7 & 8	1.05 Ω	50 ma	950595	VA163A	-	30 ma	Flexguide 254-9	-	Extension 950355B	5-2
649E	7 & 8	1.05 Ω	50 ma	950630	VA164A	-	30 ma	Flexguide 254-11	-	Extension 950612B	5-2

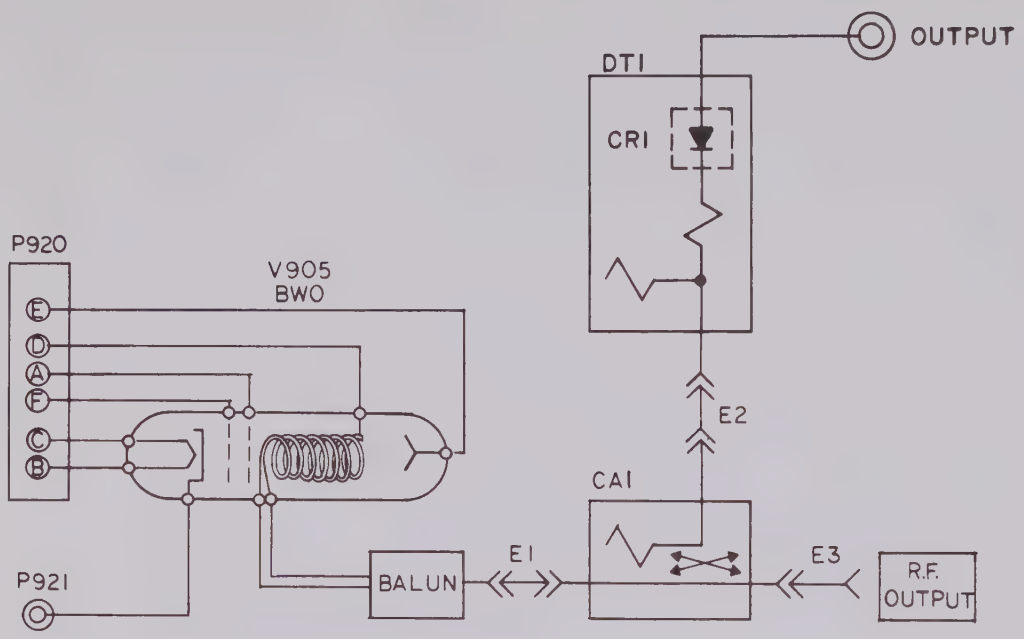

OUTPUT
DTI
CR1
P920
V905
BWO
E
D
A
F
C
B
E2
CA1
P921
BALUN
E1
E3
R.F.
OUTPUT

FIG. 5-1

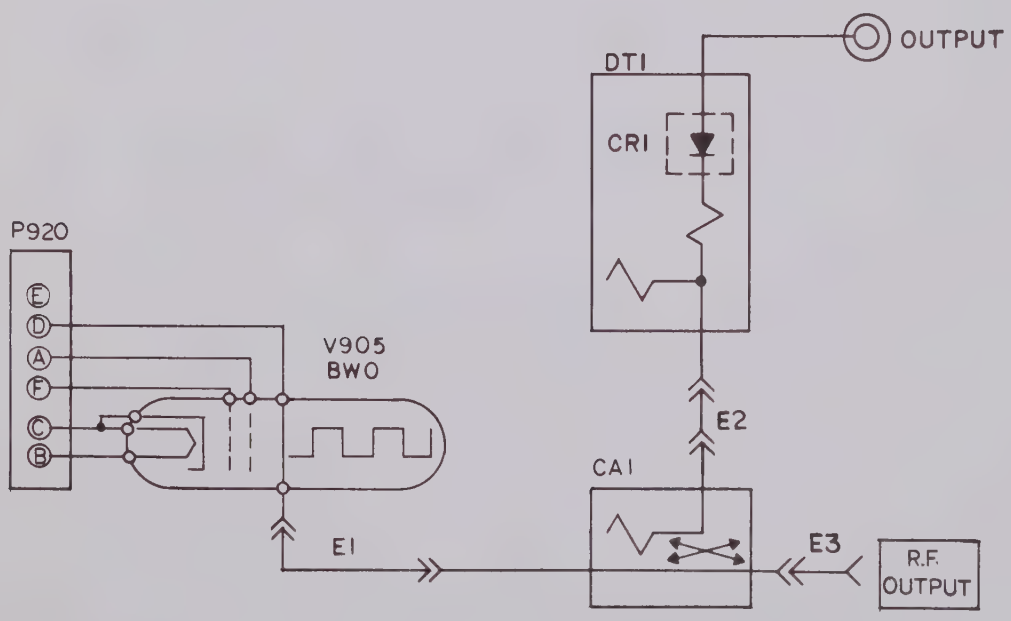

OUTPUT
DTI
CR1
P920
V905
BWO
E
D
A
F
C
B
E2
CA1
E1
E3
R.F.
OUTPUT

FIG. 5-2

SECTION 6
PARTS LIST

The following parts list is arranged in two groups according to Page number: Pages 6-1 thru 6-6 contain those parts which are common to all 640 Series instruments, and Pages 6-6 thru 6-9 contain those parts which vary from model to model.

For the units listed on Pages 6-6 thru 6-9 (parts which vary from model to model) the following letter designations are used;

640 ( ) Sweeper without internal sampler.

640K ( ) Sweeper which includes internal sampler.

The following letters designate the tube manufacturer.

(B) Stewart, PM Focused

(E) Varian

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
C101 and C102	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C103	12-15	Capacitor, fixed, ceramic, .002 mf, 500 v
C104	12-2	Capacitor, fixed, ceramic, .001 mf, 500 v
C105	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C106	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C107 thru C110	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C111	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C112	12-27	Capacitor, fixed, ceramic, 270 pf, 500 v
C113	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C114	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C115	12-22	Capacitor, fixed, ceramic, 100 pf, 500 v
A2C1 and A2C2	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
A2C3	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
A2C4 and A2C5	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
A2C6	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
A2C7	13-40	Capacitor, fixed, elect., 100 mf, 10 v
A2C8	13-33	Capacitor, fixed, elect., 10 mf, 100 v
A2C9	12-34	Capacitor, fixed, ceramic, .1 mf, 400 v
A2C10	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C301	12-2	Capacitor, fixed, ceramic, .001 mf, 500 v
C302	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C303	12-2	Capacitor, fixed, ceramic, .001 mf, 500 v
C304		Not used
C305	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C306 and C307	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C308	12-24	Capacitor, fixed, ceramic, 390 pf, 500 v
C309	12-2	Capacitor, fixed, ceramic, .001 mf, 500 v
C310	12-31	Capacitor, fixed, ceramic, .002 mf, 500 v
*C312	11-2	Capacitor, fixed, mica, 24 pf, 500 v
C313	12-18	Capacitor, fixed, ceramic, 200 pf, 500 v
C401	12-9	Capacitor, fixed, ceramic, .05 mf, 75 v
C402	12-21	Capacitor, fixed, ceramic, 27 pf, 500 v
C403	12-9	Capacitor, fixed, ceramic, .05 mf, 75 v
C404	12-21	Capacitor, fixed, ceramic, 27 pf, 500 v
C405	12-9	Capacitor, fixed, ceramic, .05 mf, 75 v
C406	12-21	Capacitor, fixed, ceramic, 27 pf, 500 v
C501	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C502 and C503	14-26	Capacitor, fixed, paper, .01 mf, 200 v ± 2%
C504 thru C506	12-27	Capacitor, fixed, ceramic, 270 pf
C507	12-22	Capacitor, fixed, ceramic, 270 pf
C601		Not used
C602 and C603	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C604	13-44	Capacitor, fixed, elect., 5 mf, 50 v
C605	13-49	Capacitor, fixed, elect., 50 mf, 10 v
C606	12-44	Capacitor, fixed, ceramic, 5 mf, 50 v
C607		Not used
C608	12-31	Capacitor, fixed, ceramic, .002 mf, 75 v
C609		Not used
C610	12-26	Capacitor, fixed, ceramic, 500 pf, 1000 v
C701	14-23	Capacitor, fixed, paper, 10 mf, 200 v
C702	14-24	Capacitor, fixed, paper, 1 mf, 200 v
C703	14-25	Capacitor, fixed, paper, .1 mf, 200 v
C704	14-26	Capacitor, fixed, paper, .01 mf, 200 v
C750	12-31	Capacitor, fixed, ceramic, .002 mf, 500 v
C751	12-36	Capacitor, fixed, feed thru, 1000 pf, 500 v
C752	12-31	Capacitor, fixed, ceramic, .022 mf, 500 v
C753 and C754	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C755	12-22	Capacitor, fixed, ceramic, 100 pf, 500 v
C756	12-42	Capacitor, fixed, ceramic, 39 pf, 1000 v
C757	12-12	Capacitor, fixed, ceramic, 30 pf, 6 kv
C758	12-27	Capacitor, fixed, ceramic, 270 pf, 1000 v
C759	12-12	Capacitor, fixed, ceramic, 30 pf, 6 kv
C760	12-21	Capacitor, fixed, ceramic, 27 pf, 500 v
C761	12-7	Capacitor, fixed, ceramic, 5 pf, 500 v
C762		Not used
C763	12-7	Capacitor, fixed, ceramic, 5 pf, 500 v
C764 and C765	12-3	Capacitor, fixed, ceramic, .01 mf, 600 v
C766	12-36	Capacitor, fixed, feed thru, 1000 pf, 500 v
C801	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C802	13-49	Capacitor, fixed, elect., 50 mf, 25 v
C803	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C804 and C805	13-51	Capacitor, fixed, elect., 10 mf, 150 v
C806 and C807	12-3	Capacitor, fixed, ceramic, .01 mf, 500 v
C808	13-48	Capacitor, fixed, elect., 1 mf, 450 v
C809	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C901	13-46	Capacitor, fixed, elect., 150 mf/150 v, 100 mf/50 v
C902	13-38	Capacitor, fixed, elect., 100 mf, 250 v
C903	13-54	Capacitor, fixed, elect., 80/50 mf, 150 v
C904	12-28	Capacitor, fixed, ceramic, .001 mf, 6 kv
C905	12-17	Capacitor, fixed, ceramic, .005 mf, 1000 v
C906	12-28	Capacitor, fixed, ceramic, .001 mf, 6 kv
C907 and C908	15-18	Capacitor, fixed, oil, 2 mf, 2 kv
C909	12-28	Capacitor, fixed, ceramic, .001 mf, 6 kv
C910	13-36	Capacitor, fixed, elect., 100/100 mf, 50 v
C911	13-38	Capacitor, fixed, elect., 100 mf, 250 v
C912	12-30	Capacitor, fixed, ceramic, 1.5 pf, 6 kv
C913	13-42	Capacitor, fixed, elect., 10 mf, 450 v dc
C914	12-28	Capacitor, fixed, ceramic, .001 mf, 6 kv
C915	13-35	Capacitor, fixed, elect., 500 mf, 25 v dc
C916	12-17	Capacitor, fixed, ceramic, .005 mf, 1000 v
C917 and C918	13-42	Capacitor, fixed, elect., 10 mf, 450 v dc
C919		Not used
C920	13-9	Capacitor, fixed, elect., 3000 mf, 15 v
C921	12-28	Capacitor, fixed, ceramic, .001 mf, 6 kv
C922		Not used
C923	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C924 thru C926	12-34	Capacitor, fixed, ceramic, .1 mf, 100 v
C927 and C928	12-33	Capacitor, fixed, ceramic, .01 mf, 3000 v
C929	12-2	Capacitor, fixed, ceramic, .001 mf, 500 v
CR101 thru CR103	81-41	Diode, 1N459
CR104	136-24	Diode, 1N3041A, zener

*Factory Selected

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
A2CR1	81-75	Diode, 1N923
A2CR2 and A2CR3	81-41	Diode, 1N459
CR301 thru CR308	81-41	Diode, 1N459
CR401 thru CR412	81-41	Diode, 1N459
CR501	81-60	Diode, HD1811
CR502 thru CR505	81-41	Diode, 1N459
CR601 thru CR604	81-41	Diode, 1N459
CR701	81-41	Diode, 1N459
CR750 and CR751	81-60	Diode, HD1811
CR801	81-77	P.S.I. 18199 or 1N752A, zener, 5.6 A, 10%
CR802	81-75	Diode, 1N823, zener, 6.2 v
CR803	81-20	Diode, DI-46/1N4385
CR804	81-38	Diode, 6.5 v zener (HR 6.5)
CR805	81-38	Diode, HR 6.5
CR806 thru CR811	81-41	Diode, 1N459
CR901 thru CR907	81-20	Diode, DI-46/1N4395
CR908	81-69	Diode, DI-1154
CR909 thru CR912	81-20	Diode, DI-46/1N4385
CR913		Not used
CR914 and CR915	81-93	Diode, MR322R
CR916 thru CR918	81-41	Diode, 1N459
CR919	81-77	Diode, 1N752A, zener
CR920	81-41	Diode, 1N459
Q101	81-85	Transistor, 2N2484
Q102 thru Q106	81-92	Transistor, 2N706
Q107 and Q108	81-72	Transistor, 2N699
Q109 and Q110	81-115	Transistor, 2N3565
A2Q1	81-71	Transistor, 2N697
A2Q2 and A2Q3	81-114	Transistor, 2N3638A
A2Q4	81-113	Transistor, SP9965
A2Q5 thru A2Q7	81-114	Transistor, 2N3638A
A2Q8	81-113	Transistor, SP9965
A2Q9 and A2Q10	81-114	Transistor, 2N3638A
A2Q11	81-71	Transistor, 2N697
A2Q12	81-114	Transistor, 2N3638A
A2Q13	81-72	Transistor, 2N699
Q301 thru Q303	81-115	Transistor, 2N3565
Q304	81-90	Transistor, S6793
Q305	81-73	Transistor, 2N706
Q306	81-114	Transistor, 2N3638A
Q307	81-72	Transistor, 2N699
Q308 and Q309	81-116	Transistor, S18563/2N3646
Q310 and Q311	81-114	Transistor, 2N3638A
Q312 and Q313	81-116	Transistor, S18563/2N3646
Q314	81-73	Transistor, 2N706/2N3646
Q315		Not used
Q401 and Q402	81-90	Transistor, S6793
Q403	81-114	Transistor, 2N3638A
Q404	81-51	Transistor, 2N404
Q405 and Q406	81-114	Transistor, 2N3638A
Q407 and Q408	81-90	Transistor, S6793
Q409	81-114	Transistor, 2N3638A
Q410	81-51	Transistor, 2N404
Q411 and Q412	81-114	Transistor, 2N3638A
Q413 and Q414	81-90	Transistor, S6793
Q415	81-114	Transistor, 2N3638A
Q416	81-51	Transistor, 2N404
Q417 thru Q419	81-114	Transistor, 2N3638A
Q501 and Q502	81-108	Transistor, SS102
Q503 thru Q506	81-73	Transistor, 2N706
Q601 and Q602	81-90	Transistor, S6793
Q603 and Q604	81-32	Transistor, 2N1499
Q605 thru Q612	81-73	Transistor, 2N706
Q613	81-51	Transistor, 2N404
Q614	81-73	Transistor, 2N706
Q615	81-71	Transistor, 2N697
Q701	81-71	Transistor, 2N697
Q702 thru Q704	81-51	Transistor, 2N404
Q705	81-72	Transistor, 2N699
Q750	81-32	Transistor, 2N1499
Q751	81-73	Transistor, 2N706
Q752	81-115	Transistor, 2N3565
Q801	81-71	Transistor, 2N697
Q802	81-51	Transistor, 2N404
Q803	81-72	Transistor, 2N699
Q804 thru Q807	81-51	Transistor, 2N404
Q808	81-72	Transistor, 2N699
Q809	81-73	Transistor, 2N706
Q810	81-51	Transistor, 2N404
Q811 and Q812	81-90	Transistor, S6793
Q901	81-89	Transistor, 2N1537
Q902	81-74	Transistor, 2N1540
Q903 and Q904	81-86	Transistor, 2N2147
Q905	81-112	Transistor, RCA 40251
Q906	81-77	Transistor, 2N697

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
R101 and R102	41-22 K	Resistor, fixed, comp., 22 K, 1/2 w, 10%
R103		Not used
R104	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R105 and R106	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
R107	41-330 Ω	Resistor, fixed, comp., 330 Ω, 1/2 w, 10%
R108		Not used
R109	41-100 Ω	Resistor, fixed, comp., 1/2 w, 10%
R110	43-4.9 K	Resistor, fixed, comp., 3.9 K, 2 w, 10%
R111	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R112	41-3.9 K	Resistor, fixed, comp., 3.9 K, 1/2 w, 10%
R113	41-1.2 K	Resistor, fixed, comp., 1.2 K, 1/2 w, 10%
R114	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10%
R115	42-4.7 K	Resistor, fixed, comp., 4.7 K, 1 w, 10%
R116 thru R118	57-15 K	Resistor, fixed, metal film, 15 K, 1/2w, 1/2%
R119	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10%
R120	56-15 K	Resistor, fixed, metal film, 15 K, 1/2 w, 1%
R121	71-94	Resistor, variable, Borg, 5 K
R122	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R123	41-150 K	Resistor, fixed, comp., 150 K, 1/2 w, 10%
R124	41-1.8 K	Resistor, fixed, comp., 1.8 K, 1/2 w, 10%
R125	71-90	Resistor, variable, Borg, 200 Ω
R126	56-1 K	Resistor, fixed, metal film, 1 K, 1/2 w, 1%
R127	41-150 K	Resistor, fixed, comp., 150 K, 1/2 w, 10%
R128	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
A2R1	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
A2R2	43-10 K	Resistor, fixed, comp., 10 K, 2 w, 10%
A2R3	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
A2R4	56-19.6 K	Resistor, fixed, metal film, 19.6 K, 1/2 w, 1%
A2R5	44-1 Ω	Resistor, fixed, B.W., 1 Ω, 1/2 w, 5%
A2R6 and A2R7	56-19.6 K	Resistor, fixed, metal film, 19.6 K, 1/2 w, 10%
A2R8	41-22 Ω	Resistor, fixed, comp., 22 Ω, 1/2 w, 10%
A2R9	71-90	Resistor, variable, 20 turn WW, 200 Ω
A2R10 and A2R11	56-1.21 K	Resistor, fixed, metal film, 1.21 K, 1/2 w, 1%
A2R12	44-1 Ω	Resistor, fixed, BW, 1 Ω, 1/2 w, 5%
A2R13	41-1.5 K	Resistor, fixed, comp., 1.5 K, 1/2 w, 10%
A2R14	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%
A2R15	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
A2R16	41-820 Ω	Resistor, fixed, comp., 820 Ω, 1/2 w, 10%
A2R17	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
A2R18	71-90	Resistor, variable, 20 turn, WW, 200 Ω
A2R19	56-1.21 K	Resistor, fixed, metal film, 1.21 K, 1/2 w, 1%
A2R20	56-19.6 K	Resistor, fixed, metal film, 19.6 K, 1/2 w, 1%
A2R21	56-19.6 K	Resistor, fixed, metal film, 19.6 K, 1/2 w, 1%
A2R22	56-19.6 K	Resistor, fixed, metal film, 19.6 K, 1/2 w, 1%
A2R23	41-330 Ω	Resistor, fixed, comp., 330 Ω, 1/2 w, 10%
A2R24	56-1.21 K	Resistor, fixed, metal film, 1.21 K, 1/2w, 1%
A2R25	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
A2R26	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
A2R27	56-4.99 K	Resistor, fixed, metal film, 4.99 K, 1/2 w, 1%
A2R28	56-34 K	Resistor, fixed, metal film, 34 K, 1/2 w, 1%
A2R29	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
A2R30	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
A2R31	56-15 K	Resistor, fixed, metal film, 15 K, 1/2 w, 1%
A2R32	56-49.9 K	Resistor, fixed, metal film, 49.9 K, 1/2 w, 1%
A2R33	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
*A2R34	41-10 Ω	Resistor, fixed, comp., 10 Ω, 1/2 w, 10%
A2R35	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
A2R36	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
A2R37	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
A2R38	41-1.2 K	Resistor, fixed, comp., 1.2 K, 1/2 w, 10%
A2R39	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
A2R40	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
A2R41 and A2R42	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R301	41-220 K	Resistor, fixed, comp., 220 K, 1/2 w, 10%
R302	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
R303	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
R304	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R305	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
R306	41-220 K	Resistor, fixed, comp., 220 K, 1/2 w, 10%
R307	56-4.99 K	Resistor, fixed, metal film, 4.99 K, 1/2 w, 1%
R308	56-12.1 K	Resistor, fixed, metal film, 12.1 K, 1/2 w, 1%
R309	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10%
R310	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R311	41-18 K	Resistor, fixed, comp., 18 K, 1/2 w, 10%
R312	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R313	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
R314	41-1.8 M	Resistor, fixed, comp., 1.8 M, 1/2 w, 10%
R315	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
R316	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%
R317	41-39 K	Resistor, fixed, comp., 39 K, 1/2 w, 10%
R318	41-470 Ω	Resistor, fixed, comp., 470 K, 1/2 w, 10%
R319	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R320	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R321	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10%
R322	41-120 K	Resistor, fixed, comp., 120 K, 1/2 w, 10%
R323	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R324	41-470 K	Resistor, fixed, comp., 470 K, 1/2 w, 10%
R325	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R326	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
R327	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R328	41-15 M	Resistor, fixed, comp., 15 M, 1/2 w, 10%
R329 and R330	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R331	41-22 K	Resistor, fixed, comp., 22 K, 1/2 w, 10%
R332	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10%
R333	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R334	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R335	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
R336	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
R337	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R338	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R339 and R340	41-220 K	Resistor, fixed, comp., 220 K, 1/2 w, 10%
R341	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
R342	41-1.8 K	Resistor, fixed, comp., 1.8 K, 1/2 w, 10%
R343	41-22 Ω	Resistor, fixed, comp., 22 Ω, 1/2 w, 10%
R344	41-270 Ω	Resistor, fixed, comp., 270 Ω, 1/2 w, 10%
R345	41-39 K	Resistor, fixed, comp., 39 K, 1/2 w, 10 %
R401	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R402	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R403 thru R405	57-100 K	Resistor, fixed, metal film, 100 K, 1/2 w, 1/2%
R406	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
R407	71-94	Resistor, variable, 15 turn, Borg, 5 K
R408	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R409	41-2.7 K	Resistor, fixed, comp., 2.7 K, 1/2 w, 10%
R410	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R411	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R412	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R413	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R414	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%

* Factory Selected

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
R415	41-47 Ω	Resistor, fixed, comp., 47 Ω, 1/2 w, 10%
R416	41-1 M	Resistor, fixed, 1 M, 1/2 w, 10%
R417	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R418	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R419	41-180 K	Resistor, fixed, comp., 180 K, 1/2 w, 10%
R420	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R421	56-4.99 K	Resistor, fixed, metal film, 4.99 K, 1/2 w, 1%
R422	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R423	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R424	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R425		Not used
R426	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R427	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R428 thru R430	57-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 1/2%
R431	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R432	71-94	Resistor, variable, 15 turn, Borg, 5 K
R433	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R434	41-68 K	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R435	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R436	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R437	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R438	41-47 Ω	Resistor, fixed, comp., 47 Ω, 1/2 w, 10%
R439	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R440	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R441	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R442	41-180 K	Resistor, fixed, comp., 180 K, 1/2 w, 10%
R443	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R444	56-4.99 K	Resistor, fixed, metal film, 4.99 K, 1/2w,1%
R445	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R446	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R447	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R448	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
R449	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R450	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R451 thru R453	57-100 K	Resistor, fixed, metal film, 100 K, 1/2w,1/2%
R454	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R455	71-94	Resistor, variable, 15 turn, Borg, 5 K
R456	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R457	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R458	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R459	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R460	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R461	41-47 Ω	Resistor, fixed, comp., 47 Ω, 1/2 w, 10%
R462	41-1 M	Resistor, fixed, comp., 1 M, 1/2 w, 10%
R463	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R464	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R465	41-180 K	Resistor, fixed, comp., 180 K, 1/2 w, 10%
R466	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R467	56-4.99 K	Resistor, fixed, metal film, 4.99 K, 1/2w,1%
R468	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R469	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R470	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R471		Not used
R472	56-10 K	Resistor, fixed, metal film, 10 K, 1/2 w, 1%
R473	41-18 K	Resistor, fixed, comp., 18 K, 1/2 w, 10%
R474	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R475	41-150 K	Resistor, fixed, comp., 150 K, 1/2 w, 10%
R476	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R501	41-150 Ω	Resistor, fixed, comp., 150 Ω, 1/2 w, 10%
R502	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10 %
R503	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R504 and R505	56-56.2 K	Resistor, fixed, comp., 56.2 K, 1/2 w, 1%
R506	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R507	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R508	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R509 and R510	41-22 K	Resistor, fixed, comp., 22 K, 1/2 w, 10%
R511	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%
R512	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R513	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R514	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R514	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R515	41-220 Ω	Resistor, fixed, comp., 220 Ω, 1/2 w, 10%
R516	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%
R517	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R518	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%
R519	41-6.8 K	Resistor, fixed, comp., 6.8 K, 1/2 w, 10%
R520	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R521	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%
R522	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R523	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R524	41-1.2 K	Resistor, fixed, comp., 1.2 K, 1/2 w, 10%
R525	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R526	42-10 K	Resistor, fixed, comp., 10 K, 1 w, 10%
R527	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
R528	41-6.8 K	Resistor, fixed, comp., 6.8 K, 1/2 w, 10%
R529	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R530		Not used
R601	41-330 K	Resistor, fixed, comp., 330 K, 1/2 w, 10%
R602	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R603	71-94	Resistor, variable, 15 turn, 5 K
R604	41-1.5 K	Resistor, fixed, comp., 1.5 K, 1/2 w, 10%
R605	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R606	41-6.8 K	Resistor, fixed, comp., 6.8 K, 1/2 w, 10%
R607	41-1.5 K	Resistor, fixed, comp., 1.5 K, 1/2 w, 10%
R608	41-220 K	Resistor, fixed, comp., 220 K, 1/2 w, 10%
R609 and R610	41-150 K	Resistor, fixed, comp., 150 K, 1/2 w, 10%
R611	71-94	Resistor, variable, 15 turn, 5 K
R612	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
R613 and R614	41-47 Ω	Resistor, fixed, comp., 47 Ω, 1/2 w, 10%
R615	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
R616	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%
R617	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R618	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R619	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%
R620	41-2.7 K	Resistor, fixed, comp., 2.7 K, 1/2 w, 10%
R621	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R622	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R623	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R624	41-1.5 K	Resistor, fixed, comp., 1.5 K, 1/2 w, 10%
R625		Not used
*R626	41-180 Ω	Resistor, fixed, comp., 180 Ω, 1/2 w, 10%
R627	41-1.2 K	Resistor, fixed, comp., 1.2 K, 1/2 w, 10%
R628		Not used
R629	41-330 K	Resistor, fixed, comp., 330 K, 1/2 w, 10%
R630 thru R632	41-1.5 K	Resistor, fixed, comp., 1.5 K, 1/2 w, 10%
R633 and R634	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R635	41-390 Ω	Resistor, fixed, comp., 390 Ω, 1/2 w, 10%
R636	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R637	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%

* Factory Selected

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
R638		Not used
R639	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10%
R640 and		
R641	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R642	41-6.8 K	Resistor, fixed, comp., 6.8 K, 1/2 w, 10%
R643	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10 %
R644	41-3.3 K	Resistor, fixed, comp., 3.3 K, 1/2 w, 10%
R645	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R646	41-82 K	Resistor, fixed, comp., 82 K, 1/2 w, 10%
R647	41-2.7 K	Resistor, fixed, comp., 2.7 K, 1/2 w, 10%
R648	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
R649	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R650	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
R651	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R701	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R702	41-6.8 K	Resistor, fixed, comp., 6.8 K, 1/2 w, 10%
R703	71-90	Resistor, variable, Borg, 200 Ω
R704	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10%
R705	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R706	56-1.78 K	Resistor, fixed, metal film, 1.78 K, 1/2 w, 1%
R707	56-866 Ω	Resistor, fixed, metal film, 866 Ω, 1/2 w, 1%
R708	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R709	71-90	Resistor, variable, Borg, 200 Ω
R710	56-1.62 K	Resistor, fixed, metal film, 1.62 K, 1/2 w,1%
R711	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10%
R712		Not used
R713		Not used
R714	56-49.9 Ω	Resistor, fixed, metal film, 49.9 Ω, 1/2 w,1%
R715	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R716	56-1 K	Resistor, fixed, metal film, 1 K, 1/2 w, 1%
R717	43-3.9 K	Resistor, fixed, comp., 3.9 K, 2 w, 10%
R718	43-8.2 K	Resistor, fixed, comp., 8.2 K, 2 w, 10%
R719	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R750 and		
R751	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
R752	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R753	41-2.2 K	Resistor, fixed, comp., 2.2 K, 1/2 w, 10%
R754	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R755	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R756	41-5.6 K	Resistor, fixed, comp., 5.6 K, 1/2 w, 10%
R757 thru		
R760	37-47 Ω	Resistor, fixed, comp., 47 Ω, 1/4 w, 10%
R761	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R762	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R801 and		
R802	41-39 Ω	Resistor, fixed, comp., 39 Ω, 1/2 w, 10%
R803	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R804	41-150 Ω	Resistor, fixed, comp., 150 Ω, 1/2 w, 10%
R805	71-96	Resistor, variable, 15 turn, 100 Ω
R806	41-220 Ω	Resistor, fixed, comp., 220 Ω, 1/2 w, 10%
R807	43-2.2 K	Resistor, fixed, comp., 2.2 K, 2 w, 10 %
R808	41-39 K	Resistor, fixed, comp., 39 K, 1/2 w, 10%
R809	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R810	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%
R811	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R812	41-10 Ω	Resistor, fixed, comp., 10 Ω, 1/2 w, 10%
R813 and		
R814	41-3.9 K	Resistor, fixed, comp., 3.9 K, 1/2 w, 10%
R815	56-34 K	Resistor, fixed, metal film, 34 K, 1/2 w, 1%
*R816	56-8.25 K	Resistor, fixed, metal film, 8.25 K, 1/2 w,1%
R817	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R818	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10%
R819	43-4.7 K	Resistor, fixed, comp., 4.7 K, 2 w, 10%
R820	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
R821	71-95	Resistor, variable, 15 turn, 2 K
R822	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R823	56-23.7 K	Resistor, fixed, metal film, 23.7 K, 1/2 w, 1%
R824	56-1.69 K	Resistor, fixed, metal film, 1.69 K, 1/2 w, 1%
R825	41-220 K	Resistor, fixed, comp., 220 K, 1/2 w, 10%
R826	41-4.7 K	Resistor, fixed, comp., 4.7 K, 1/2 w, 10%
R827		Not used
R828	71-92	Resistor, variable, 20 turn, 20 K
R829	56-17.8 K	Resistor, fixed, metal film, 17.8 K, 1/2 w, 1%
R830	56-100 K	Resistor, fixed, metal film, 100 K, 1/2 w, 1%
R831		See Addendum sheet "A"
R832	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%
R901 and		
R902	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R903	43-68 Ω	Resistor, fixed, comp., 68 Ω, 2 w, 10%
R904 and		
R905	41-100 K	Resistor, fixed, comp., 100 K, 1/2 w, 10%
R906 and		
R907	41-10 Ω	Resistor, fixed, comp., 10 Ω, 1/2 w, 10%
R908	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R909	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
R910	41-56 Ω	Resistor, fixed, comp., 56 Ω, 1/2 w, 10%
R911	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R912	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
R913	41-56 Ω	Resistor, fixed, comp., 56 Ω, 1/2 w, 10%
R914	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%
R915	41-100 Ω	Resistor, fixed, comp., 100 Ω, 1/2 w, 10%
R916	41-56 Ω	Resistor, fixed, comp, 56 Ω, 1/2 w, 10%
R917 thru		
R922	55-40	Resistor, fixed, metal film, 464 K, 1 w, 1%
R923	43-68 K	Resistor, fixed, comp., 68 K, 2 w, 10%
R924	62-1	Resistor, fixed, WW, 10 K, 10 w, 5%
R925	41-22 K	Resistor, fixed, comp., 22 K, 1/2 w, 10%
R926 and		
R927	74-6	Resistor, variable, 10 turn, 1%, Beckman, 1 K
R928	71-82	Resistor, variable, 10 K, 20T
R929	74-6	Resistor, variable, 2 w, 10%,100 Ω
R930	71-72	Resistor, variable, 2 w, 10%, 100 Ω
R931 and		
R932	74-6	Resistor, variable, 10 turn, 1%, 1 K, Beckman
R933	55-4	Resistor, fixed, WW, 12.5 Ω, 1/2 w, 1%
R934	56-10	Resistor, fixed, WW, 10 Ω, 1/2 w, 1%
R935		Not used
R936	56-16.2 Ω	Resistor, fixed, metal film, 16.2 Ω, 1/2 w, 1%
R937	71-77	Resistor, variable, 1/2 w, 10 K, 20%
R938	71-77	Resistor, variable, 20%, 10 K
R939 and		
R940	52-200 K	Resistor, fixed, metal film, 200 K, 2 w, 5%
R941 thru		
R943	52-200 K	Resistor, fixed, metal film, 200 K, 2 w, 5%
R944	61-22	Resistor, fixed, comp., 8 M, 4 w, 5 kv, 20%
R945	56-383 K	Resistor, fixed, metal film, 383 K, 1/2 w, 1%
R946	71-71	Resistor, variable, 1/2 w, V taper, 5 M, 10%
R947	61-13	Resistor, fixed, WW, 2.5 K, 5 w, 10%
R948	41-27 Ω	Resistor, fixed, comp., 27 Ω, 1/2 w, 10%
R949	61-15	Resistor, fixed, WW, 3.6 Ω, 5 w, 3%
R950	63-11	Resistor, fixed, WW, 15 K, 20 w, 5%
R951	41-150 K	Resistor, fixed, comp., 150 K, 1/2 w, 10%
R952	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R953 and		
R954	42-15 K	Resistor, fixed, comp., 15 K, 1 w, 10%
R955	45-4.7 Ω	Resistor, fixed, comp., 4.7 Ω, 1 w, 5%

* Factory Selected

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	
R956 thru R959	56-16.2 Ω	Resistor, fixed, metal film, 16.2 Ω, 1/2 w, 1%	
R960	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%	
R961	41-8.2 K	Resistor, fixed, comp., 8.2 K, 1/2 w, 10%	
R962	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%	
R963	41-10 M	Resistor, fixed, comp., 10 M, 1/2 w, 10%	
R964	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%	
R965	42-1 M	Resistor, fixed, 1 M, 1 w, 10%	
R966	56-69.8 K	Resistor, fixed, M. F., 69.8 K, 1/2 w, 1%	
R967	50-68 K	Resistor, fixed, tin oxide, 68 K, 2 w, 10%	
R968	56-18.7 K	Resistor, fixed, metal film, 18.7 K, 1/2 w, 1%	
R969	42-100 Ω	Resistor, fixed, comp., 100 Ω, 1 w, 10%	
R970	41-470 Ω	Resistor, fixed, comp., 470 Ω, 1/2 w, 10%	
R971	41-10 Ω	Resistor, fixed, comp., 10 Ω, 1/2 w, 10%	
R972	62-1	Resistor, fixed, comp., 10 K, 10 w, 10%	
R973	41-10 Ω	Resistor, fixed, comp., 10 Ω, 1/2 w, 10%	
R974	41-1 K	Resistor, fixed, comp., 1 K, 1/2 w, 10%	
L750	92-18	Inductor, 1 mh, coil, RF	
L751	92-26	Inductor, .33 mh, coil, RF	
L752 thru L757	92-5	Inductor, 33 mh, coil, RF	
T901	91-195	Transformer, Tranex 4-0896 (ALFRED Spec. #950601)	
T902	91-185	Transformer, Tranex 4-0588 (ALFRED Spec. #950202)	
K701	106-24	Relay, SPDT, 10 K, coil (P and B R SSD)	
K901	106-25	Relay, time delay (Amperite 6N060)	
K902	106-18	Relay, 110 v dc, 3 PDT (P and B KA2270)	
K903	106-30	Relay, 100 v dc (K A 1466-1)	
K904	106-29	Relay, RS5D, 6 v dc	
S901	101-18	Switch, pushbutton (Switchcraft 201)	
S902	102-131	Switch, rotary 630902 (rf output)	
S903	102-121	Switch, rotary 630903 (sweep time)	
S904	102-129	Switch, rotary 630904 (modulation)	
S905	102-122	Switch, rotary 630905 (sweep trigger)	
S906	102-130	Switch, rotary 630906 (frequency)	
S907		Not used	
S908	101-5	Switch, toggle, DPST	
S909	101-17	Switch, snap action (Cherry E33-20A)	
S910	101-17	Switch, snap action (Cherry E33-20A)	
S911	102-128	Switch, lever (630-911)	
S912	101-8	Switch, pushbutton (normally closed)	
S913	102-136	Switch, slide	
S914	102-32	Switch, rotary 630914 (single frequency)	
S915	101-19	Switch, pushbutton (Switchcraft 963)	

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	
V901 thru V903	111-8068	Vacuum tube, electron, 8068	
V904	111-6CW5	Vacuum tube, electron, 6CW5	
F901	121-3	Fuse, 3 ampere, 3 AG, 250 v	
F902	121-8	Fuse, 8 ampere, 3 AG, 250 v	
F903	121-3	Fuse, 3 ampere, 3 AG, 250 v	
DS901 and DS902	126-9	Bulb, indicator, panel (Leecraft #32-1111T)	
DS903	126-1	Bulb, neon NE-2	
M901	87-3	Meter, elapsed time indicator	

PARTS WHICH VARY FROM MODEL TO MODEL

Models 641B, 641KB

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TOTAL QTY.
R10	56-127 K	Resistor, fixed, metal film, 127 K, 1/2 w, 1%	
R11	56-178 K	Resistor, fixed, metal film, 178 K, 1/2 w, 1%	
R12	56-422 K	Resistor, fixed, metal film, 422 K, 1/2 w, 1%	
R13	56-412 K	Resistor, fixed, metal film, 412 K, 1/2 w, 1%	
R14	56-487 K	Resistor, fixed, metal film, 487 K, 1/2 w, 1%	
R15	56-536 K	Resistor, fixed, metal film, 536 K, 1/2 w, 1%	
R16	56-402 K	Resistor, fixed, metal film, 402 K, 1/2 w, 1%	
R17	56-392 K	Resistor, fixed, metal film, 392 K, 1/2 w, 1%	
R18	56-324 K	Resistor, fixed, metal film, 324 K, 1/2 w, 1%	
R19	56-511 K	Resistor, fixed, metal film, 511 K, 1/2 w, 1%	
R20	56-383 K	Resistor, fixed, metal film, 383 K, 1/2 w, 1%	
R21	41-18 K	Resistor, fixed, comp., 18 K, 1/2 w, 10%	
R22	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%	
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%	
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%	
CR11 thru CR22	81-41	Diode, 1N459	

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		Model 641B-S1 and Model 641KB-S1
R10	56-110 K	Resistor, fixed, metal film, 110 K, 1/2 w, 1%
R11	56-402 K	Resistor, fixed, metal film, 402 K, 1/2 w, 1%
R12	56-324 K	Resistor, fixed, metal film, 324 K, 1/2 w, 1%
R13	56-698 K	Resistor, fixed, metal film, 698 K, 1/2 w, 1%
R14	56-649 K	Resistor, fixed, metal film, 649 K, 1/2 w, 1%
R15	56-453 K	Resistor, fixed, metal film, 453 K, 1/2 w, 1%
R16	56-604 K	Resistor, fixed, metal film, 604 K, 1/2 w, 1%
R17	56-576 K	Resistor, fixed, metal film, 576 K, 1/2 w, 1%
R18	56-365 K	Resistor, fixed, metal film, 365 K, 1/2 w, 1%
R19	56-576 K	Resistor, fixed, metal film, 576 K, 1/2 w, 1%
R20	56-464 K	Resistor, fixed, metal film, 464 K, 1/2 w, 1%
R21	41-22 K	Resistor, fixed, comp., 22 K, 1/2 w, 10%
R22	41-39 K	Resistor, fixed, comp., 39 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
		Model 642B and Model 642KB
R10	56-124 K	Resistor, fixed, metal film, 124 K, 1/2 w, 1%
R11	56-143 K	Resistor, fixed, metal film, 143 K, 1/2 w, 1%
R12	56-422 K	Resistor, fixed, metal film, 422 K, 1/2 w, 1%
R13	56-274 K	Resistor, fixed, metal film, 274 K, 1/2 w, 1%
R14	56-412 K	Resistor, fixed, metal film, 412 K, 1/2 w, 1%
R15	56-301 K	Resistor, fixed, metal film, 301 K, 1/2 w, 1%
R16	56-237 K	Resistor, fixed, metal film, 237 K, 1/2 w, 1%
R17	56-348 K	Resistor, fixed, metal film, 348 K, 1/2 w, 1%
R18	56-205 K	Resistor, fixed, metal film, 205 K, 1/2 w, 1%
R19	56-210 K	Resistor, fixed, metal film, 210 K, 1/2 w, 1%
R20	56-261 K	Resistor, fixed, metal film, 261 K, 1/2 w, 1%
R21	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R22	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
		Model 642B-S1 and Model 642KB-S1
R10	56-178 K	Resistor, fixed, metal film, 178 K, 1/2 w, 1%
R11	56-143 K	Resistor, fixed, metal film, 154 K, 1/2 w, 1%
R12	56-154 K	Resistor, fixed, metal film, 154 K, 1/2 w, 1%
R13	56-825 K	Resistor, fixed, metal film, 825 K, 1/2 w, 1%
R14	56-187 K	Resistor, fixed, metal film, 187 K, 1/2 w, 1%
R15	56-261 K	Resistor, fixed, metal film, 261 K, 1/2 w, 1%
R16	56-162 K	Resistor, fixed, metal film, 162 K, 1/2 w, 1%
R17	56-147 K	Resistor, fixed, metal film, 147 K, 1/2 w, 1%
R18	56-154 K	Resistor, fixed, metal film, 154 K, 1/2 w, 1%
R19	56-294 K	Resistor, fixed, metal film, 294 K, 1/2 w, 1%
R20	56-110 K	Resistor, fixed, metal film, 110 K, 1/2 w, 1%
R21	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R22	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		Model 643B and Model 643KB
R10	56-133 K	Resistor, fixed, metal film, 133 K, 1/2 w, 1%
R11	56-137 K	Resistor, fixed, metal film, 137 K, 1/2 w, 1%
R12	56-348 K	Resistor, fixed, metal film, 348 K, 1/2 w, 1%
R13	56-309 K	Resistor, fixed, metal film, 309 K, 1/2 w, 1%
R14	56-332 K	Resistor, fixed, metal film, 332 K, 1/2 w, 1%
R15	56-261 K	Resistor, fixed, metal film, 261 K, 1/2 w, 1%
R16	56-232 K	Resistor, fixed, metal film, 232 K, 1/2 w, 1%
R17	56-237 K	Resistor, fixed, metal film, 237 K, 1/2 w, 1%
R18	56-124 K	Resistor, fixed, metal film, 124 K, 1/2 w, 1%
R19	56-237 K	Resistor, fixed, metal film, 237 K, 1/2 w, 1%
R20		Not used
R21	41-12 K	Resistor, fixed, comp., 12 K, 1/2 w, 10%
R22	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
		Model 643B-S1 and Model 643KB-S1
R10	56-100 K	Resistor, fixed, metal film, 100 K, 1/2 w, 1%
R11	56-124 K	Resistor, fixed, metal film, 124 K, 1/2 w, 1%
R12	56-287 K	Resistor, fixed, metal film, 287 K, 1/2 w, 1%
R13	56-357 K	Resistor, fixed, metal film, 357 K, 1/2 w, 1%
R14	56-324 K	Resistor, fixed, metal film, 324 K, 1/2 w, 1%
R15	56-243 K	Resistor, fixed, metal film, 243 K, 1/2 w, 1%
R16	56-261 K	Resistor, fixed, metal film, 261 K, 1/2 w, 1%
R17	56-237 K	Resistor, fixed, metal film, 237 K, 1/2 w, 1%
R18	56-205 K	Resistor, fixed, metal film, 205 K, 1/2 w, 1%
R19	56-169 K	Resistor, fixed, metal film, 169 K, 1/2 w, 1%
R20	56-200 K	Resistor, fixed, metal film, 200 K, 1/2 w, 1%
R21	41-12 K	Resistor, fixed, comp., 12 K, 1/2 w, 10%
R22	41-39 K	Resistor, fixed, comp., 39 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
		Model 643B-S2 and Model 643KB-S2
R10	56-162 K	Resistor, fixed, metal film, 162 K, 1/2 w, 1%
R11	56-121 K	Resistor, fixed, metal film, 121 K, 1/2 w, 1%
R12	56-274 K	Resistor, fixed, metal film, 274 K, 1/2 w, 1%
R13	56-267 K	Resistor, fixed, metal film, 267 K, 1/2 w, 1%
R14	56-237 K	Resistor, fixed, metal film, 237 K, 1/2 w, 1%
R15	56-205 K	Resistor, fixed, metal film, 205 K, 1/2 w, 1%
R16	56-187 K	Resistor, fixed, metal film, 187 K, 1/2 w, 1%
R17	56-147 K	Resistor, fixed, metal film, 147 K, 1/2 w, 1%
R18	56-162 K	Resistor, fixed, metal film, 162 K, 1/2 w, 1%
R19	56-100 K	Resistor, fixed, metal film, 100 K, 1/2 w, 1%
R20	56-137 K	Resistor, fixed, metal film, 137 K, 1/2 w, 1%
R21	41-10 K	Resistor, fixed, comp., 10 K, 1/2 w, 10%
R22	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459

Models 644B, 644KB; 644E, 644KE; 644E-S1, 644KE-S1

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
	Model 644B and Model 644KB	
R10	56-118 K	Resistor, fixed, metal film, 118 K, 1/2 w, 1%
R11	56-412 K	Resistor, fixed, metal film, 412 K, 1/2 w, 1%
R12	56-681 K	Resistor, fixed, metal film, 681 K, 1/2 w, 1%
R13	56-523 K	Resistor, fixed, metal film, 523 K, 1/2 w, 1%
R14	56-604 K	Resistor, fixed, metal film, 604 K, 1/2 w, 1%
R15	56-536 K	Resistor, fixed, metal film, 536 K, 1/2 w, 1%
R16 and R17	56-422 K	Resistor, fixed, metal film, 422 K, 1/2 w, 1%
R18 and R19	56-332 K	Resistor, fixed, metal film, 332 K, 1/2 w, 1%
R20	56-237 K	Resistor, fixed, metal film, 237 K, 1/2 w, 1%
R21	41-12 K	Resistor, fixed, comp., 12 K, 1/2 w, 10%
R22	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
	Model 644E and Model 644KE	
R10	56-182 K	Resistor, fixed, metal film, 182 K, 1/2 w, 1%
R11	56-619 K	Resistor, fixed, metal film, 619 K, 1/2 w, 1%
R12		Not used
R13	56-453 K	Resistor, fixed, metal film, 453 K 1/2 w, 1%
R14		Not used
R15	56-442 K	Resistor, fixed, metal film, 442 K, 1/2 w, 1%
R16	56-1.37 M	Resistor, fixed, metal film, 1.37 M, 1/2 w, 1%
R17	56-604 K	Resistor, fixed, metal film, 604 K, 1/2 w, 1%
R18	56-576 K	Resistor, fixed, metal film, 576 K, 1/2 w, 1%
R19	56-475 K	Resistor, fixed, metal film, 475 K, 1/2 w, 1%
R20	56-590 K	Resistor, fixed, metal film, 590 K, 1/2 w, 1%
R21	41-18 K	Resistor, fixed, comp., 18 K, 1/2 w, 10%
R22	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
	Model 644E-S1 and Model 644KE-S1	
R10	56-187 K	Resistor, fixed, metal film, 187 K, 1/2 w, 1%
R11	56-280 K	Resistor, fixed, metal film, 280 K, 1/2 w, 1%
R12	56-634 K	Resistor, fixed, metal film, 634 K, 1/2 w, 1%
R13	56-475 K	Resistor, fixed, metal film, 475 K, 1/2 w, 1%
R14	56-511 K	Resistor, fixed, metal film, 511 K, 1/2 w, 1%
R15	56-634 K	Resistor, fixed, metal film, 634 K, 1/2 w, 1%
R16	56-294 K	Resistor, fixed, metal film, 294 K, 1/2 w, 1%
R17	56-287 K	Resistor, fixed, metal film, 287 K, 1/2 w, 1%
R18	56-255 K	Resistor, fixed, metal film, 255 K, 1/2 w, 1%
R19	56-215 K	Resistor, fixed, metal film, 215 K, 1/2 w, 1%
R20	56-182 K	Resistor, fixed, metal film, 182 K, 1/2 w, 1%
R21	41-18 K	Resistor, fixed, comp., 18 K, 1/2 w, 10%
R22	41-68 K	Resistor, fixed, comp., 68 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459

Models 645B, 645KB; 645E, 645KE; 646B

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
	Model 645B and Model 645KB	
R10	56-80.6 K	Resistor, fixed, metal film, 80.6 K, 1/2 w, 1%
R11	56-221 K	Resistor, fixed, metal film, 221 K, 1/2 w, 1%
R12	56-442 K	Resistor, fixed, metal film, 442 K, 1/2 w, 1%
R13	56-402 K	Resistor, fixed, metal film, 402 K, 1/2 w, 1%
R14	56-309 K	Resistor, fixed, metal film, 309 K, 1/2 w, 1%
R15	56-287 K	Resistor, fixed, metal film, 287 K, 1/2 w, 1%
R16	56-274 K	Resistor, fixed, metal film, 274 K, 1/2 w, 1%
R17	56-200 K	Resistor, fixed, metal film, 200 K, 1/2 w, 1%
R18	56-205 K	Resistor, fixed, metal film, 205 K, 1/2 w, 1%
R19	56-165 K	Resistor, fixed, metal film, 165 K, 1/2 w, 1%
R20	56-137 K	Resistor, fixed, metal film, 137 K, 1/2 w, 1%
R21	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R22	41-33 K	Resistor, fixed, comp., 33 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
	Model 645E and Model 645KE	
R10	56-127 K	Resistor, fixed, metal film, 127 K, 1/2 w, 1%
R11	56-412 K	Resistor, fixed, metal film, 412 K, 1/2 w, 1%
R12	56-576 K	Resistor, fixed, metal film, 576 K, 1/2 w, 1%
R13		Not used
R14	56-332 K	Resistor, fixed, metal film, 332 K, 1/2 w, 1%
R15	56-487 K	Resistor, fixed, metal film, 487 K, 1/2 w, 1%
R16 and R17	56-412 K	Resistor, fixed, metal film, 412 K, 1/2 w, 1%
R18	56-249 K	Resistor, fixed, metal film, 249 K, 1/2 w, 1%
R19	56-365 K	Resistor, fixed, metal film, 365 K, 1/2 w, 1%
R20	56-309 K	Resistor, fixed, metal film, 309 K, 1/2 w, 1%
R21	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R22	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10%
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459
	Model 646B	
R10	56-68.1 K	Resistor, fixed, metal film, 68.1 K, 1/2 w, 1%
R11	56-226 K	Resistor, fixed, metal film, 226 K, 1/2 w, 1%
R12	56-332 K	Resistor, fixed, metal film, 332 K, 1/2 w, 1%
R13	56-412 K	Resistor, fixed, metal film, 412 K, 1/2 w, 1%
R14	56-301 K	Resistor, fixed, metal film, 301 K, 1/2 w, 1%
R15	56-316 K	Resistor, fixed, metal film, 316 K, 1/2 w, 1%
R16	56-301 K	Resistor, fixed, metal film, 301 K, 1/2 w, 1%
R17	56-191 K	Resistor, fixed, metal film, 191 K, 1/2 w, 1%
R18 and R19	56-226 K	Resistor, fixed, metal film, 226 K, 1/2 w, 1%
R20	56-143 K	Resistor, fixed, metal film, 143 K, 1/2 w, 1%
R21	41-15 K	Resistor, fixed, comp., 15 K, 1/2 w, 10%
R22	41-27 K	Resistor, fixed, comp., 27 K, 1/2 w, 10 %
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%
CR11 thru CR21	81-41	Diode, 1N459

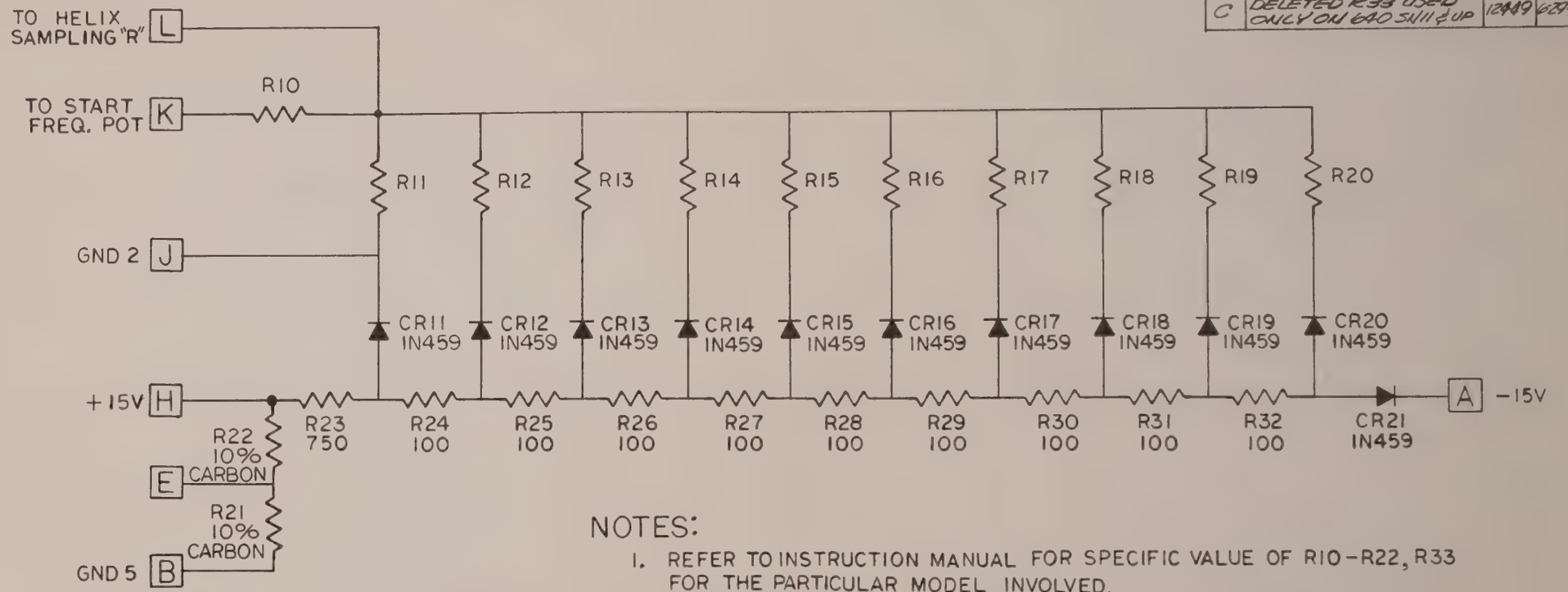
CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	
		Model 647E and Model 647KE	
R10	56-133 K	Resistor, fixed, metal film, 133 K, 1/2 w, 1%	
R11		Not used	
R12	56-1.40 M	Resistor, fixed, metal film, 1.40 M, 1/2 w, 1%	
R13	56-768 K	Resistor, fixed, metal film, 768 K, 1/2 w, 1%	
R14	56-1.40 M	Resistor, fixed, metal film, 1.40 M, 1/2 w, 1%	
R15	56-604 K	Resistor, fixed, metal film, 604 K, 1/2 w, 1%	
R16	56-866 K	Resistor, fixed, metal film, 866 K, 1/2 w, 1%	
R17	56-536 K	Resistor, fixed, metal film, 536 K, 1/2 w, 1%	
R18	56-590 K	Resistor, fixed, metal film, 590 K, 1/2 w, 1%	
R19	56-715 K	Resistor, fixed, metal film, 715 K, 1/2 w, 1%	
R20	56-604 K	Resistor, fixed, metal film, 604 K, 1/2 w, 1%	
R21	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%	
R22	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10 %	
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%	
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%	
CR11 thru CR21	81-41	Diode, 1N459	
		Model 648E	
R10	56-154 K	Resistor, fixed, metal film, 154 K, 1/2 w, 1%	
R11	56-1.33 K	Resistor, fixed, metal film, 1.33 M, 1/2 w, 1%	
R12	56-1.24 M	Resistor, fixed, metal film, 1.24 M, 1/2 w, 1%	
R13	56-953 K	Resistor, fixed, metal film, 953 K, 1/2 w, 1%	
R14	56-909 K	Resistor, fixed, metal film, 909 K, 1/2 w, 1%	
R15	56-750 K	Resistor, fixed, metal film, 750 K, 1/2 w, 1%	
R16	56-825 K	Resistor, fixed, metal film, 825 K, 1/2 w, 1%	
R17	56-634 K	Resistor, fixed, metal film, 634 K, 1/2 w, 1%	
R18	56-649 K	Resistor, fixed, metal film, 649 K, 1/2 w, 1%	
R19	56-442 K	Resistor, fixed, metal film, 442 K, 1/2 w, 1%	
R20	56-324 K	Resistor, fixed, metal film, 324 K, 1/2 w, 1%	
R21	41-47 K	Resistor, fixed, comp., 47 K, 1/2 w, 10%	
R22	41-56 K	Resistor, fixed, comp., 56 K, 1/2 w, 10%	
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 10%	
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%	
CR11 thru CR21	81-41	Diode, 1N459	
		Model 649E	
R10	56-102 K	Resistor, fixed, metal film, 102 K, 1/2 w, 1%	
R11	56-340 K	Resistor, fixed, metal film, 340 K, 1/2 w, 1%	
R12	56-845 K	Resistor, fixed, metal film, 845 K, 1/2 w, 1%	
R13	56-562 K	Resistor, fixed, metal film, 562 K, 1/2 w, 1%	
R14	56-523 K	Resistor, fixed, metal film, 523 K, 1/2 w, 1%	
R15	56-432 K	Resistor, fixed, metal film, 432 K, 1/2 w, 1%	
R16	56-402 K	Resistor, fixed, metal film, 402 K, 1/2 w, 1%	
R17	56-365 K	Resistor, fixed, metal film, 365 K, 1/2 w, 1%	
R18	56-294 K	Resistor, fixed, metal film, 294 K, 1/2 w, 1%	
R19	56-274 K	Resistor, fixed, metal film, 274 K, 1/2 w, 1%	
R20	56-221 K	Resistor, fixed, metal film, 221 K, 1/2 w, 1%	
R21	41-22 K	Resistor, fixed, comp., 22 K, 1/2 w, 10%	
R22	41-39 K	Resistor, fixed, comp., 39 K, 1/2 w, 10%	
R23	56-750 Ω	Resistor, fixed, metal film, 750 Ω, 1/2 w, 1%	
R24 thru R32	56-100 Ω	Resistor, fixed, metal film, 100 Ω, 1/2 w, 1%	
CR11 thru CR21	81-41	Diode, 1N459	

SECTION 7

SCHEMATICS

Circuit	PC Board Number	Reference Designation Prefix	Schematic Number
Diode Shaper	10	10	900604B
Cathode Supply	100	100	900599C
Low Voltage Power Supplies	A2	A2	900766C
Sweep Circuit	300	300	900600C
Markers Circuit	400	400	900652C
Square Wave and Modulator	500	500	900678C
Leveler Circuit	600	600	900721C
Helix Overcurrent	700	700	900598C
Transfer Oscillator	750	750	900675C
Elevated Supply	800	800	900677C
Chassis	-	900	900669D

SYM	DESCRIPTION	NO	DATE	BY
A	APPD. FOR PRODUCTION	~	9-25-3	D.P.
B	ADDED USAGE ON 640 ADDED R33 & * EFFECTIVE ON ALL SER. NO.	~	12-19-3	D.P.
C	DELETED R33 USED ONLY ON 640 SN111 & UP	12949	6-20-4	V.L.



NOTES:

1. REFER TO INSTRUCTION MANUAL FOR SPECIFIC VALUE OF R10-R22, R33 FOR THE PARTICULAR MODEL INVOLVED.
2. UNLESS OTHERWISE SPECIFIED:
   2A. ALL RESISTORS IN OHMS, 1/2W, 1%, METAL FILM.
3. SQUARE ( ) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC900.

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

SER. NO. 11-UP	640
SER. NO. 18-UP	630
NEXT ASSY	USED ON

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN	Dave Presley	9-25-63
ENG	Ralph Britton	9/30/63
PROD	Hans D. Julius	9-30-63
SCALE		

SCHEMATIC - DIODE SHAPER

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900604B

SHEET 1 OF 1

SYM	DESCRIPTION	NO.	DATE	BY
L	Q109 WAS 2N706 Q110 WAS 2N2484 S/N 420 & UP (630) S/N 242 & UP (640)	12700	4-15-65	MN

SYM	DESCRIPTION	NO	DATE	BY
A	APPD. FOR PRODUCTION	—	9/10/3	D.P.
B	C103 WAS .002, R109 WAS 150Ω	12140	9/10/3	D.P.
C	R120 WAS 12.1K	12155	9/30/3	D.P.
D	C103 WAS .005	12156	9/30/3	D.P.
E	ADDED 2N2484 TO Q101 & Q110 AS ALTERNATIVE	12172	10/14/3	D.P.
F	C105, C107-C110 WERE .1/75V EFFECTIVE FOR S.N. 117-UP	12200	11/4/63	D.P.
G	ADDED C114, .1, 100V EFFECTIVE FOR S.N. 17-UP	12201	11/4/63	D.P.
H	ADDED USAGE ON MODEL 6AC SERIES	~	12-20-3	D.P.
I	R107 WAS 470Ω SEE 17-UP(630) SEE 11-UP(640)	12582	12-23-4	D.P.
J	R107 WAS 220Ω, R109 WAS 39Ω, C112 WAS 27PF, S.N 11-UP ON BOTH	12582A	1-5-65	D.P.
K	ADDED C115, 9/N 11-UP	12620	2-8-5	DP

AC FEEDBACK T
F1 OR F0 INPUT N
F2 OR SWEEP INPUT R
FM EXT JACK S
GND 2 W
+15V E
GND 5 H J K
-50V A
DC FEEDBACK X

R101 22K
R102 22K
R105 2.2K
R106 2.2K
R109 100
C103 .002
R128 10K
R127 150K
R104 470
R107 330
C115 100 PF
C113 .01
R116 15K 1/2%, M.F.
Q101 2N2483 OR 2N2484
Q102 2N706
Q103 2N706
Q104 2N706
Q105 2N706
Q106 2N706
Q107 2N699
C101 .01
C106 .01
R111 15K
R112 3.9K
R113 1.2K
R117 15K 1/2%, M.F.
C104 .001
C105 .1 100V
R118 15K 1/2%, M.F.
R120 15K 1%, M.F.
C112 270PF
R121 5K W.W.
END FREQ ADJ
R126 1K 1%, M.F.
START FREQ ADJ
R125 200 W.W.
R124 1.8K
C114 .1 100V
C109 .1 100V
E +15V
Q109 2N3565
Q110 2N3565
R119 27K
CR101 IN459
CR102 IN459
CR103 IN459
C107 .1 100V
R122 10K
R123 150K
C108 .1 100V
CR104 IN3041A
C102 .01
R110 3.9K 2W
C111 .01
Q108 2N699
R114 27K
R115 4.7K 1W
C110 .1 100V
D +100V
C OUTPUT TO 8068 GRIDS
F -15V
Y TO FEEDBACK SHAPING CIRCUIT

NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2 SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC100, ASSEMBLY NO. 950287.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			

MATERIAL
MATERIAL STOCK NO.
FINISH OR TREATMENT

DRAWN Dave Presley 7-1-63
ENG. Ralph Butler 9-10-63
PROD Ken L. Anderson 9-10-63
SCALE

SCHEMATIC — CATHODE SUPPLY

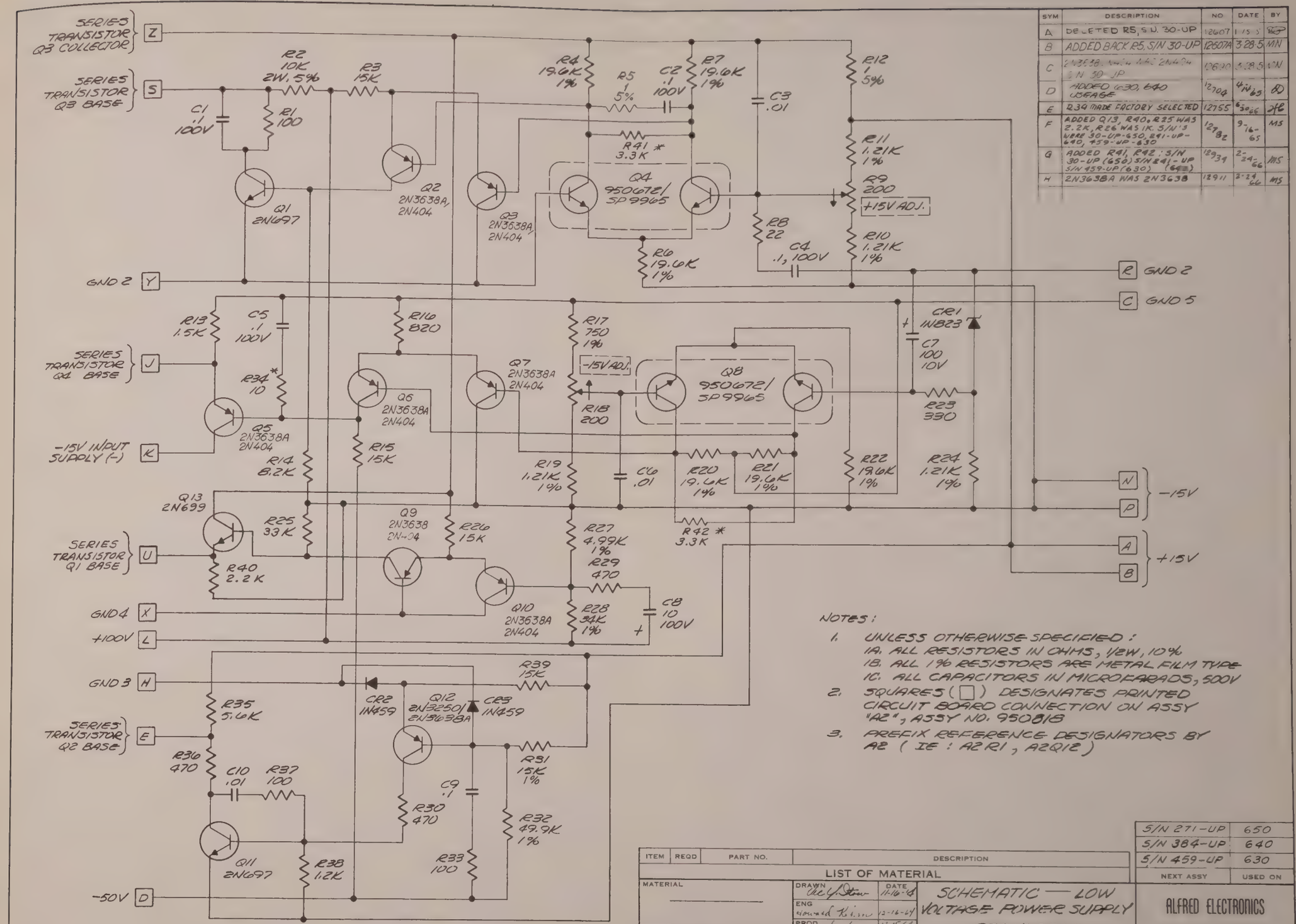
DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

SER. NO. 11-UP	640
SER. NO. 17-UP	630
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900599C

SHEET 1 OF 1



* FACTORY SELECTED

SYM	DESCRIPTION	NO.	DATE	BY
A	DELETED R5, S/N 30-UP	12607	1-15-65	
B	ADDED BACK R5, S/N 30-UP	12607A	3-28-65	MN
C	2N3638, WAS 2N404 S/N 30 UP	12620	3-28-65	MN
D	ADDED C630, 640 USEAGE	12704	4-14-65	RD
E	234 MADE FACTORY SELECTED	12755	6-30-66	JHB
F	ADDED Q13, R40, R25 WAS 2.2K, R26 WAS 1K. S/N'S WERE 30-UP, 650, 271-UP-640, 459-UP-630	12782	9-16-65	MS
G	ADDED R41, R42; S/N 30-UP (650) S/N 271-UP S/N 459-UP (630) (640)	12939	2-24-66	MS
H	2N3638A WAS 2N3638	12911	2-24-66	MS

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%
   1B. ALL 1% RESISTORS ARE METAL FILM TYPE
   1C. ALL CAPACITORS IN MICROFARADS, 500V
2. SQUARES (□) DESIGNATES PRINTED CIRCUIT BOARD CONNECTION ON ASSY "A2", ASSY NO. 950818
3. PREFIX REFERENCE DESIGNATORS BY A2 (IE : A2R1, A2Q1)

ITEM	REQD	PART NO.	DESCRIPTION
			LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN Chas. G. Stevens DATE 11-16-64

ENG Edmund K. Sinn 12-16-64

PROD Hans L. Andersen 12-15-64

SCALE

SCHEMATIC — LOW VOLTAGE POWER SUPPLY REGULATOR

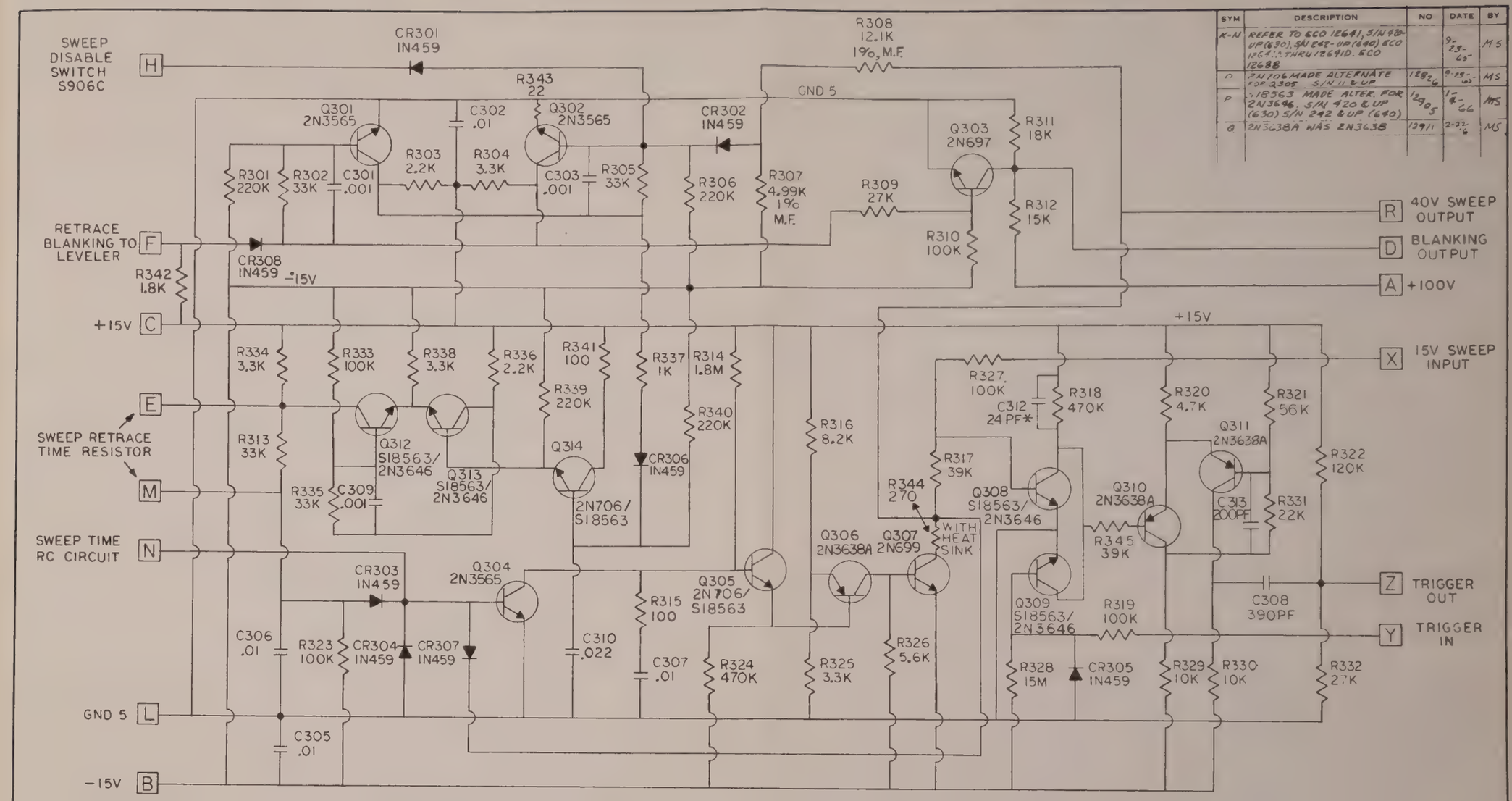
DIMENSIONS ARE IN INCHES
TOL: .XX ± .015. .XXX ± .005. ANGLE ± ½°
UNLESS INDICATED OTHERWISE

S/N 271-UP	650
S/N 384-UP	640
S/N 459-UP	630
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900766C-2

SHEET 1 OF 1



SYM	DESCRIPTION	NO	DATE	BY
K-N	REFER TO ECO 12641, S/N 98-UP (630), SN 242-UP (640) ECO 12641 THRU 12691D. ECO 12688		9-23-63	MS
O	2N706 MADE ALTERNATE FOR Q305 S/N 11 & UP	12826	9-25-63	MS
P	S18563 MADE ALTER. FOR 2N3646, S/N 420 & UP (630) S/N 242 & UP (640)	12905	1-14-64	MS
Q	2N3638A WAS 2N3638	12911	2-27-64	MS

NOTES:

1. UNLESS OTHERWISE SPECIFIED
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC300, ASSEMBLY NO. 950276.

* FACTORY SELECTED

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL	
MATERIAL STOCK NO.	
FINISH OR TREATMENT	

DRAWN	Dave Presley	7-9-63
ENG	Ralph Butler	9-10-63
PROD	Ken Anderson	
SCALE		

SCHEMATIC – SWEEP CIRCUIT

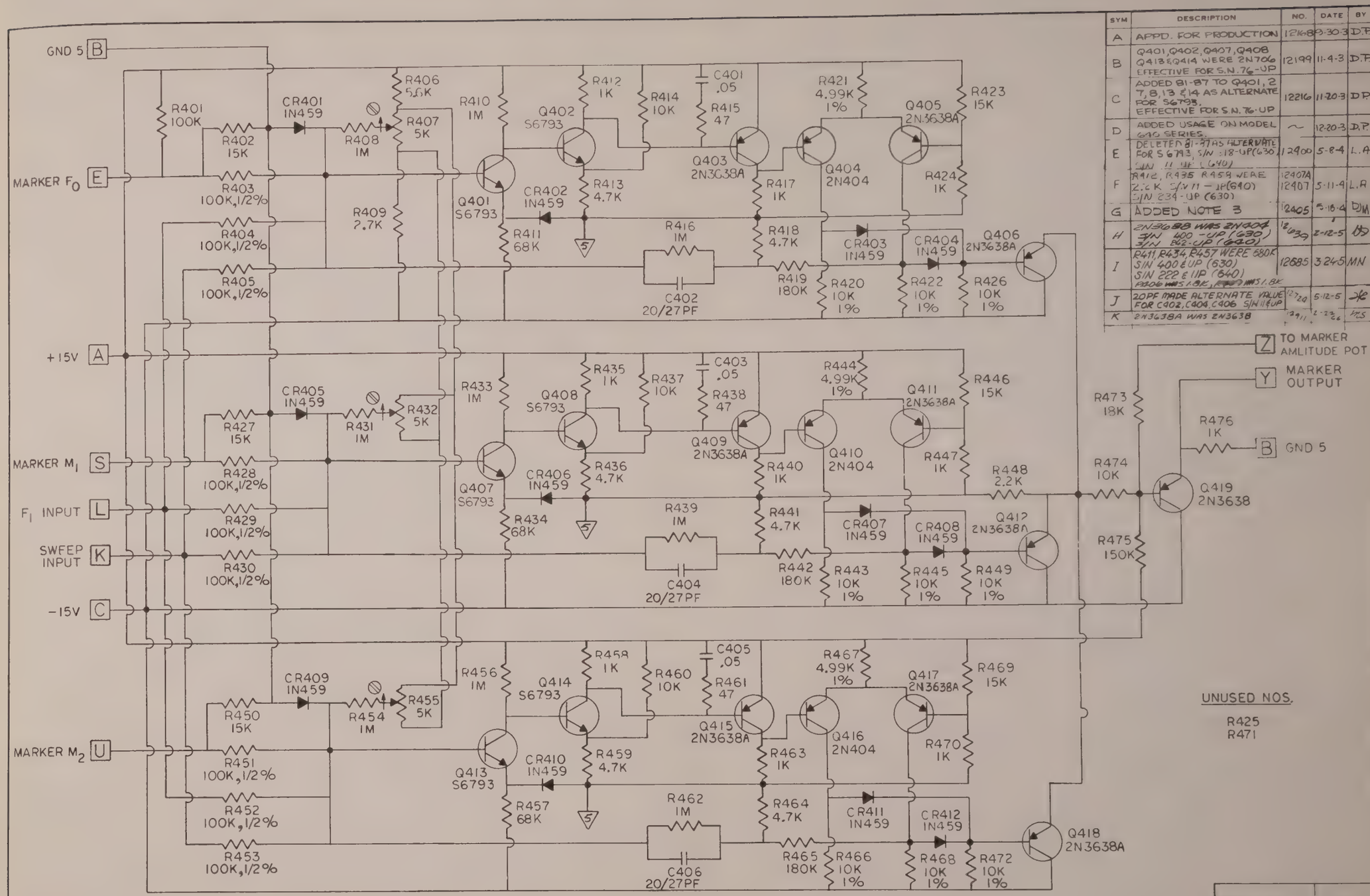
DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½° UNLESS INDICATED OTHERWISE

SER. NO. 11-UP	640
SER. NO. 178-UP	630
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900600C

SHEET 1 OF 1



SYM	DESCRIPTION	NO.	DATE	BY
A	APPD. FOR PRODUCTION	12168	9-30-3	D.P
B	Q401, Q402, Q407, Q408 Q413 & Q414 WERE 2N706 EFFECTIVE FOR S.N. 76-UP	12199	11-4-3	D.P
C	ADDED B1-B7 TO Q401, 2 7, 8, 13 & 14 AS ALTERNATE FOR S6793, EFFECTIVE FOR S.N. 76-UP	12216	11-20-3	D.P
D	ADDED USAGE ON MODEL 640 SERIES.	~	12-20-3	D.P
E	DELETED B1-B7 AS ALTERNATE FOR S6793, S/N 18-UP(630) S/N 11 UP (640)	12400	5-8-4	L.A.
F	R412, R435 R459 WERE 2.2K S/N 11-UP(640) S/N 234-UP (630)	12407A 12407	5-11-4	L.A
G	ADDED NOTE 3	12405	5-16-4	DM
H	2N3688 WAS 2N404 S/N 400-UP (630) S/N 862-UP (640)	12039	2-12-5	DP
I	R411, R434, R457 WERE 680K S/N 400 & UP (630) S/N 222 & UP (640) R406 WAS 5.6K, R407 WAS 5.6K	12685	3 24 5	MN
J	20PF MADE ALTERNATE VALUE FOR C402, C404, C406 S/N 11 & UP	12720	5-12-5	DP
K	2N3638A WAS 2N3638	12911	2-22-6	MS

UNUSED NOS.

R425
R471

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL 1/2% AND 1% RESISTORS ARE METAL FILM TYPE.
   1C. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE ( ) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC400, ASSEMBLY NO. 950369.
3. ON MODEL 640, S/N 11-119, R427 & R450 ARE 39K.

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

		DATE
DRAWN	Dave Presley	9-27-63
ENG	Ralph Britton	10/1/63
PROD	Jim Nelson	9-30-63
SCALE		

SCHEMATIC — MARKERS CIRCUIT

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

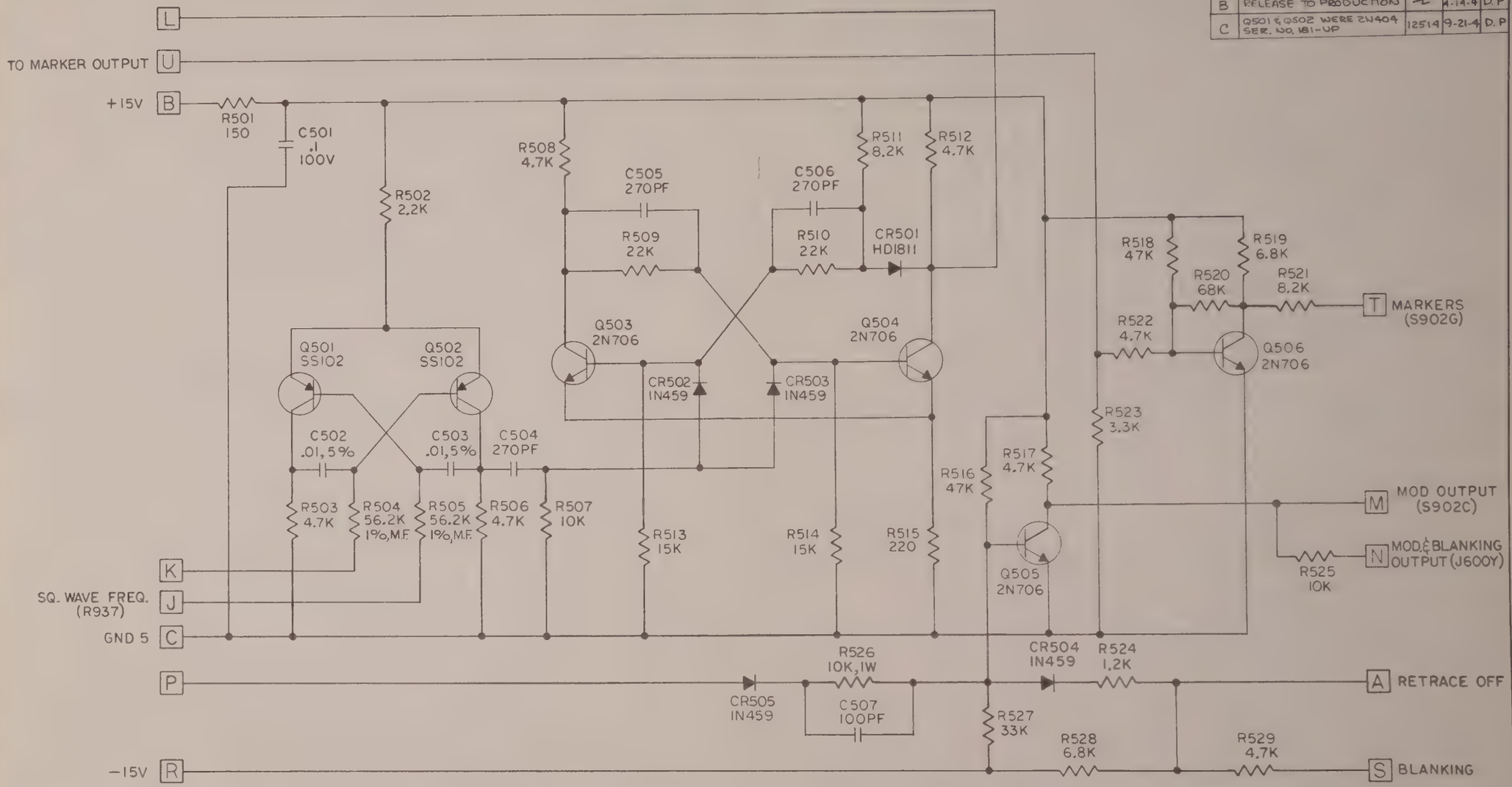
SER. NO. 11-UP	640
SER. NO. 76-UP	630
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900652C

SHEET 1 OF 1

SYM	DESCRIPTION	NO	DATE	BY
A	REVISED PIN CONNECTIONS EFF 640 S/N 21-UP	~	4-7-4	DP
B	RELEASE TO PRODUCTION	~	4-14-4	D.P
C	Q501 & Q502 WERE 2N404 SER. NO. 181-UP	12514	9-21-4	D. P



NOTES

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE(□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC500, ASSEMBLY NO. 950529.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			

MATERIAL	DRAWN Dave Presley	DATE 12-18-3
MATERIAL STOCK NO	ENG	4-14-64
FINISH OR TREATMENT	PROD	4-14-64
SCALE		

SCHEMATIC — SQUARE WAVE & MOD.

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

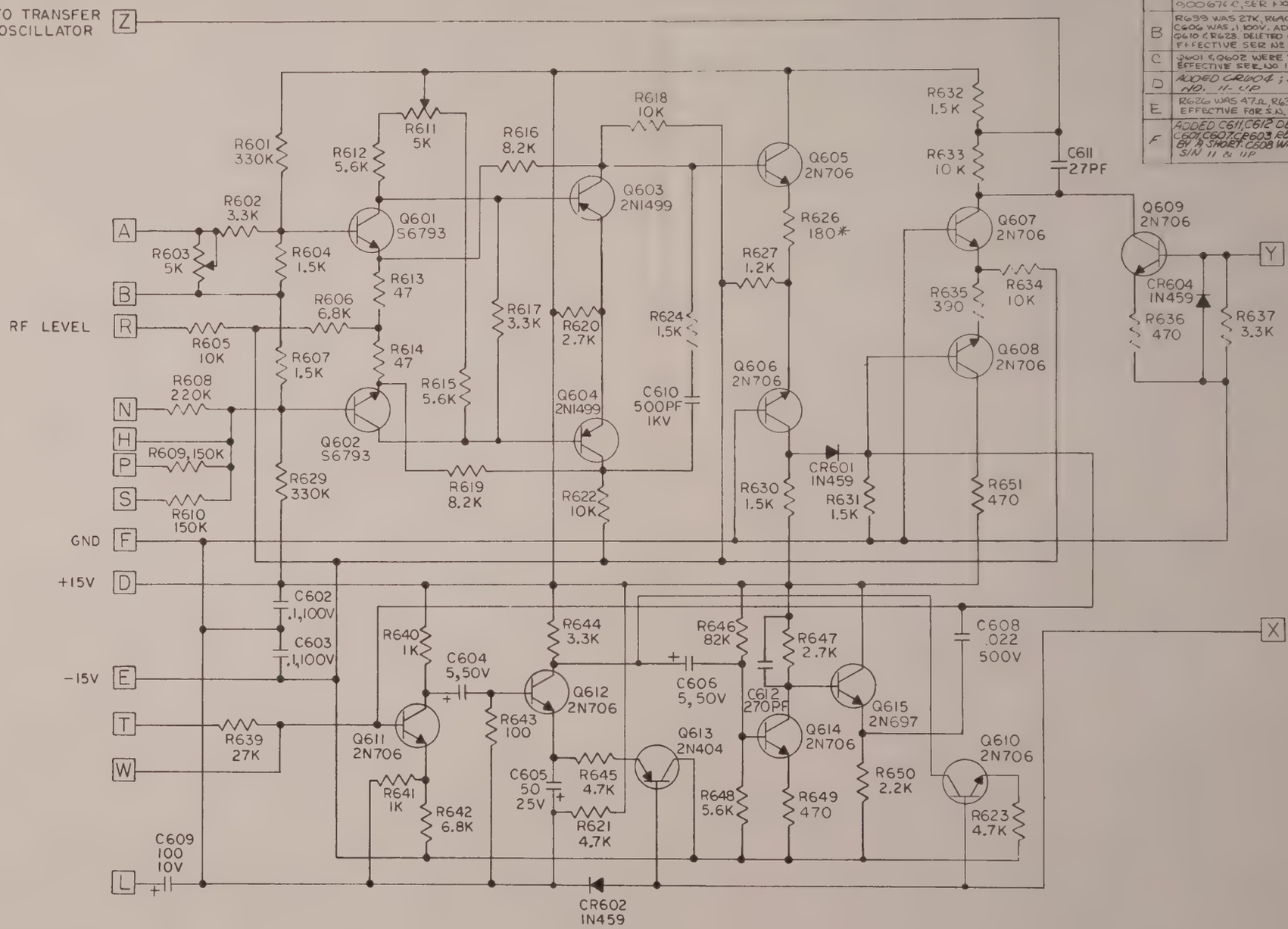
SER.NO. 11-UP	640
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900678C

SHEET 1 OF 1

SYM	DESCRIPTION	NO.	DATE	BY
A	APP'D. FOR PRODUCTION THIS SCHEMATIC REPLACES 900676C, SER NO. 11-UP	12447	6-19-4	D P
B	R639 WAS 27K, R640 WAS 4.7K C606 WAS .1 100V. ADDED Q610 & R623. DELETED CONN "U" EFFECTIVE SER NO 11-UP	12452	7-2-4	D.P.
C	Q601 & Q602 WERE 2N706 EFFECTIVE SER NO 11-UP	12467	7-2-4	D.P
D	ADDED CR604 ; SER NO. 11- UP	12492	8-5-4	V.I.
E	R626 WAS 47Ω, R639 WAS 39K EFFECTIVE FOR S.N. 11-UP	12506	9-1-4	D.P
F	ADDED C611, C612 DELETED C601, C607, C603, REPLACED BY A SHORT. C608 WAS .05 S/N 11 & UP	12730 12730A 12730B	5-24-5	MN



NOTES

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS.
2. SQUARE ( ) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC600, ASSEMBLY NO. 950613.

UNUSED NOS. R625, R628, R638.

* FACTORY SELECTED

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL	DRAWN Dave Presley	DATE 12-10-3
MATERIAL STOCK NO	ENG	
FINISH OR TREATMENT	PROD	
	SCALE	

SCHEMATIC - LEVELER AMP.

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

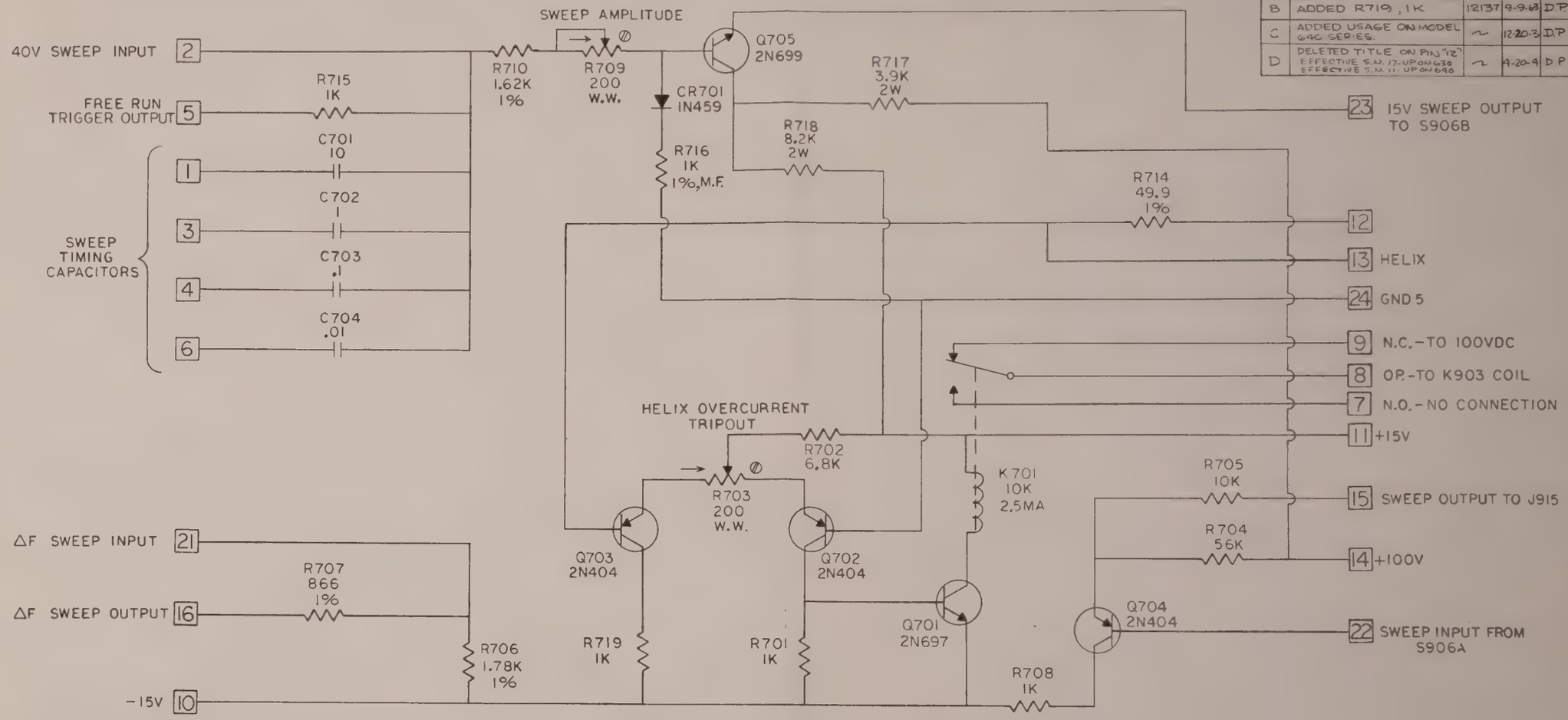
SER. NO. 11-UP	640
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900721C

SHEET 1 OF 1

SYM	DESCRIPTION	NO	DATE	BY
A	APPD. FOR PRODUCTION	~	9-9-63	D.P.
B	ADDED R719, 1K	12137	9-9-63	D.P.
C	ADDED USAGE ON MODEL 640 SERIES.	~	12-20-3	D.P.
D	DELETED TITLE ON PIN "12" EFFECTIVE S.N. 17-UP ON 630 EFFECTIVE S.N. 11-UP ON 640	~	4-20-4	D P



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   - 1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   - 1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARES (□) DESIGNATE TERMINAL LUG CONNECTIONS ON PRINTED CIRCUIT PC700, ASSEMBLY NO. 950279.

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

		DATE
DRAWN	Dave Presley	7-10-63
ENG	Ralph Peila	9-10-63
PROD	Hans A. Andersen	9-10-63

SCALE

SCHEMATIC — HELIX OVERCURRENT

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015. .XXX ± .005. ANGLE ± ½°
UNLESS INDICATED OTHERWISE

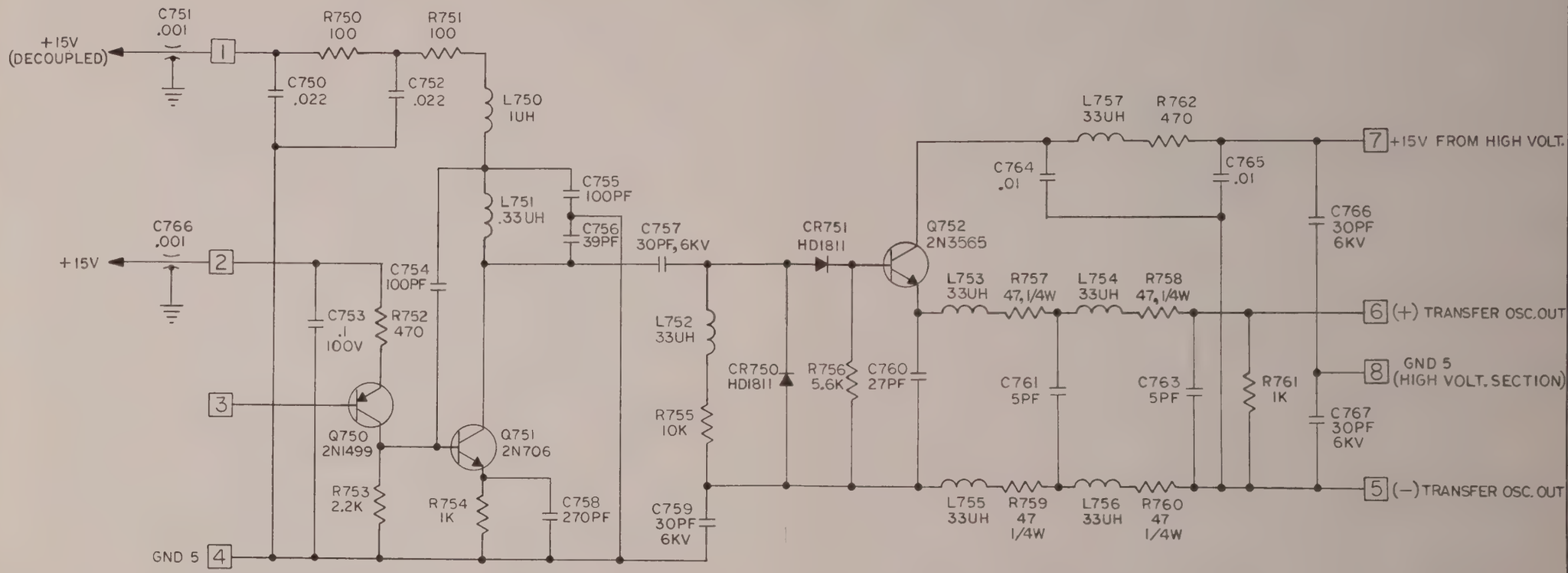
SER.NO. 11-UP	640
SER.NO. 17-UP	630
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900598C

SHEET 1 OF 1

SYM	DESCRIPTION	NO	DATE	BY
A	RELEASE TO PRODUCTION	~	4-14-4	DP
B	L751 WAS .47 UH S/N 11 & UP	12676	3-15-5	MN
C	Q752 WAS 2N706 S/N 222 & UP	12699	4-6-5	MN



C762 NOT USED

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10 %.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE(□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON ASSEMBLY NO. 950402.

ITEM	REQD	PART NO.	DESCRIPTION
LIST OF MATERIAL			

MATERIAL

MATERIAL STOCK NO

FINISH OR TREATMENT

DRAWN Dave Presley 12-19-3

ENG

PROD

SCALE

SCHEMATIC – TRANSFER OSCILLATOR

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

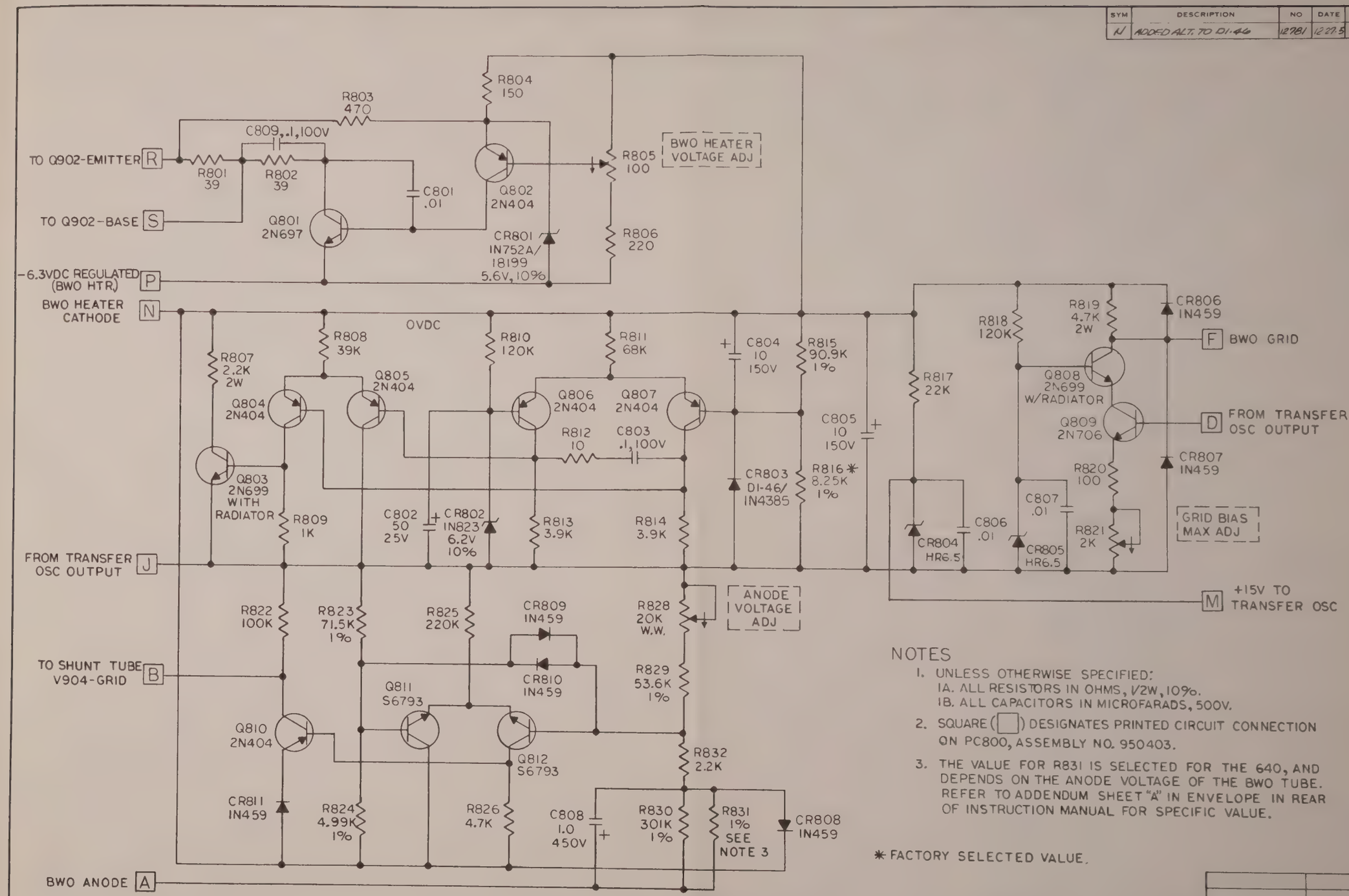
SER. NO. 11-UP	640
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900675C

SHEET 1 OF 1

SYM	DESCRIPTION	NO	DATE	BY
N	ADDED ALT. TO D1-46	12781	12-27-5	DO



NOTES

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC800, ASSEMBLY NO. 950403.
3. THE VALUE FOR R831 IS SELECTED FOR THE 640, AND DEPENDS ON THE ANODE VOLTAGE OF THE BWO TUBE. REFER TO ADDENDUM SHEET "A" IN ENVELOPE IN REAR OF INSTRUCTION MANUAL FOR SPECIFIC VALUE.

* FACTORY SELECTED VALUE.

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN Dave Presley DATE 12-18-3

ENG

PROD

SCALE

SCHEMATIC — ELEVATED SUPPLY

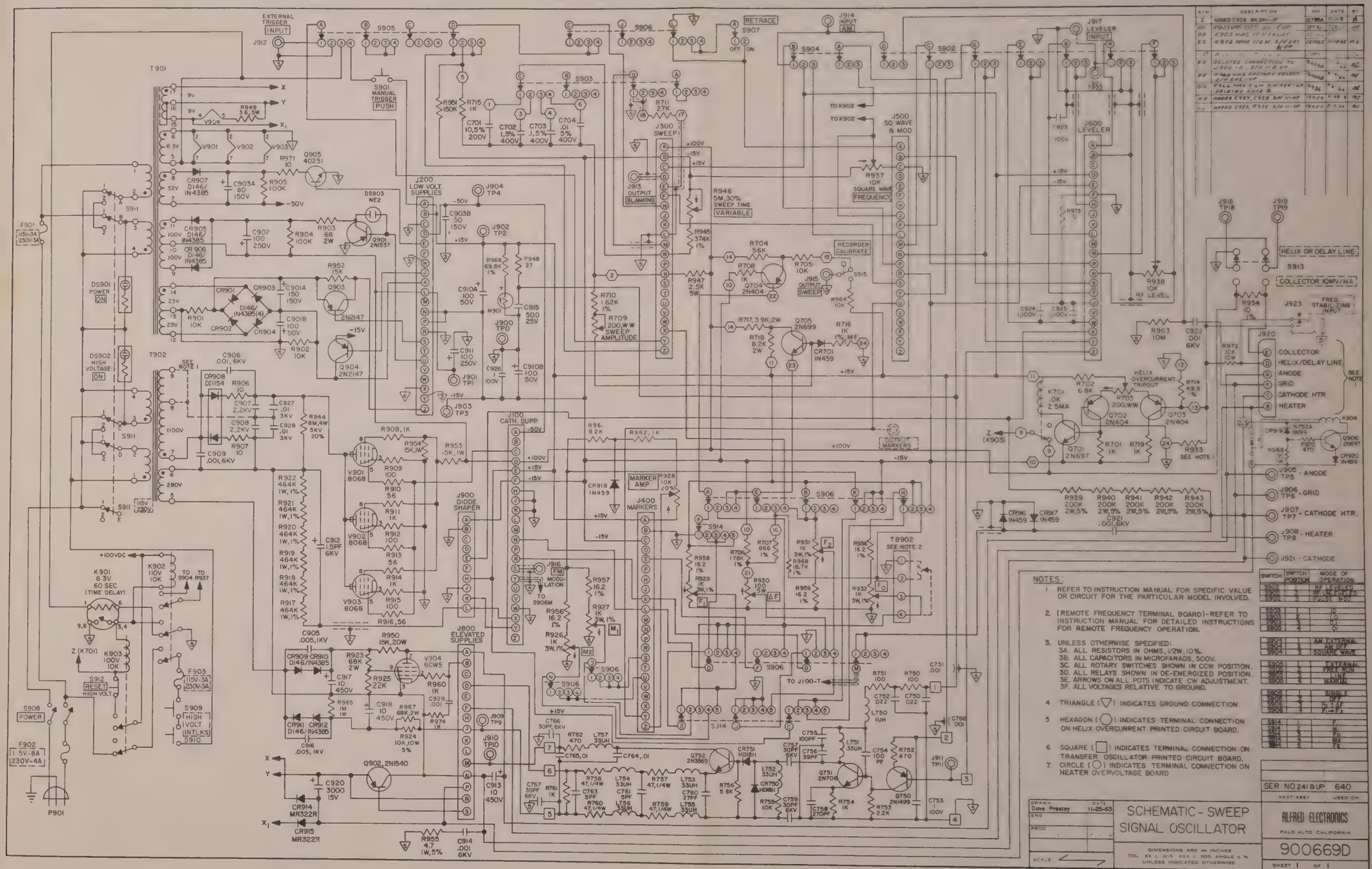
DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

SER. NO. 11—UP | 640
NEXT ASSY | USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900677C

SHEET 1 OF 1


EXTERNAL TRIGGER INPUT
J912
S905
S906
S907
RETRACE
OFF ON
J914 INPUT AM
J917 LEVELER INPUT
S904
S902
S903
T901
S901 MANUAL TRIGGER PUSH
TO K902
J500 SQ WAVE & MOD
J600 LEVELER
J913 OUTPUT BLANKING
J300 SWEEP
R946 5M, 30% SWEEP TIME VARIABLE
R937 10K SQUARE WAVE FREQUENCY
R938 10K RF LEVEL
J915 OUTPUT SWEEP
RECORDER CALIBRATE
S915
J918 TP18
J919 TP19
HELIX OR DELAY LINE
S913
COLLECTOR 10MV/MA
FREQ. STABILIZING INPUT
J923
J920
COLLECTOR
HELIX/DELAY LINE
ANODE
GRID
CATHODE HTR
HEATER
SEE NOTE 1
J200 LOW VOLT. SUPPLIES
J904 TP4
J902 TP2
J900 TPO
J901 TP1
J903 TP3
DS903 NE2
DS901 POWER ON
DS902 HIGH VOLTAGE ON
F901 115V-3A 230V-3A
S911
T902
J100 CATH. SUPP.
J900 DIODE SHAPER
J800 ELEVATED SUPPLIES
J916 FM MODULATION
TO S906M
J900 MARKERS
MARKER AMP
OUTPUT MARKERS
TB902 SEE NOTE 2
TO J100-T
K901 6.3V 60 SEC (TIME DELAY)
K902 110V 10K
K903 100V 10K
S912 RESET HIGH VOLT
S908 POWER
S909 HIGH VOLT INTLKS
S910
F902 1.5V-8A 230V-4A
F903 115V-3A 230V-3A
P901
J905 - ANODE
J906 - GRID
J907 - CATHODE HTR.
J908 - HEATER
J921 - CATHODE
J909 TP9
J910 TP10
J911 TP11
Q902, 2N1540
Q750 2N1499
Q751 2N706
Q752 2N3565
Q901 2N1537
Q903 2N2147
Q904 2N2147
Q905 40251
Q700 2N404
Q701 2N697
Q702 2N404
Q703 2N404
Q704 2N404
Q705 2N699
Q706 2N699
V901 8068
V902 8068
V903 8068
V304 6CW5
CR907 DI46/IN4385
CR908 DI1154
CR909 CR910 DI46/IN4385
CR911 CR912 DI46/IN4385
CR914 MR322R
CR915 MR322R
CR901 CR902 CR903 CR904 DI46/IN4385(4)
CR905 DI46/IN4385
CR906 DI46/IN4385
CR917 IN459
CR918 IN459
CR919 IN459
CR920 IN459
CR96 IN459
K701 .0K 2.5MA
K904
CR9-92 IN752A 18199
P370 470
R969 1K
R933 SEE NOTE 1
R939 200K 2W,5%
R940 200K 2W,5%
R941 200K 2W,5%
R942 200K 2W,5%
R943 200K 2W,5%
C921 .001,6KV
R963 10M
C922 001 6KV
R972 10K, 10W
R934 10 1%
C924 .1,100V
C925 .1,100V
C923 .1 100V
R973 10
R702 6.8K
R703 200,WW
R714 49.9 1%
R701 1K
R719 1K
R933 SEE NOTE 1
R901 10K
R902 10K
R903 68 2W
R904 100K
R905 100K
R907 10
R908, 1K
R909 100
R910 56
R911 1K
R912 100
R913 56
R914 1K
R915 100
R916, 56
R922 464K 1W, 1%
R921 464K 1W, 1%
R920 464K 1W, 1%
R919 464K 1W, 1%
R918 464K 1W, 1%
R917 464K 1W, 1%
R944 8M, 4W 5KV 20%
R945 374K 1%
R947 2.5K 5W
R948 27
R949 3.6, 5W
R950 15K, 20W
R951 150K
R952 15K
R953 15K, 1W
R954 15K, 1W
R955 4.7 1W, 5%
R956 16.2 1%
R957 16.2 1%
R958 16.2 1%
R959 16.2 1%
R960 1K
R961 10
R962, 1K
R964 10K
R965 1M 1W
R966 69.8K 1%
R967 68K, 2W
R971 10
R974 1K
R924 10K, 10W 5%
R926 1K 3W, 1%
R927 1K 3W, 1%
R928 10K 20%
R929 1K 3W, 1%
R930 100 3W
R931 1K 3W, 1%
R932 1K 3W, 1%
R936 16.2 1%
R707 866 1%
R708 178K 1%
R968 187K 1%
R709 200, WW SWEEP AMPLITUDE
R710 162K 1%
R716 1K, 1%, MF
R717, 3.9K, 2W
R718 8.2K 2W
R704 56K
R705 10K
R708 1K
R96, 8.2K
C900 .001, 6KV
C901A 150 150V
C901B 100 150V
C902 100 250V
C903A 80 150V
C903B 50 150V
C904 .01 3KV
C905 .005, 1KV
C906 .001, 6KV
C907 2.2KV
C908 2.2KV
C909 .001, 6KV
C910A 100 50V
C910B 100 50V
C911 100 250V
C912 .5PF 6KV
C913 10 450V
C914 .001 6KV
C915 500 25V
C916 .005, 1KV
C917 10 450V
C918 10 450V
C920 3000 15V
C926 .1 100V
C927 .01 3KV
C928 .01 3KV
C929 .001
C701 10,5% 200V
C702 1.5% 400V
C703 1.5% 400V
C704 .01 5% 400V
C705 .001
C706 .001
C707 .001
C708 .001
C709 .001
C710 .001
C711 .001
C712 .001
C713 .001
C714 .001
C715 .001
C716 .001
C717 .001
C718 .001
C719 .001
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C740 .001
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C742 .001
C743 .001
C744 .001
C745 .001
C746 .001
C747 .001
C748 .001
C749 .001
C750 .022
C751 .001
C752 .022
C753 .1 100V
C754 100 PF
C755 100PF
C756 39PF
C757 30PF 6KV
C758 270PF
C759 30PF 6KV
C760 27PF
C761 3PF
C762 .001
C763 5PF
C764, .01
C765, .01
C766 30PF, 6KV
C767 30PF 6KV
R750 100
R751 100
R752 470
R753 2.2K
R754 1K
R755 10K
R756 5.6K
R757 47, 1/4W
R758 47, 1/4W
R759 47, 1/4W
R760 47, 1/4W
R761 1K
R782 470
L750 1UH
L751 .33UH
L752 33UH
L753 33UH
L754 33UH
L755 33UH
L756 33UH
L757 33UH
CR750 HD1811
CR751 HD1811
T8902
K901
K902
K903
K904
K701
S914
S906
S909
S910
S911
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Tube Warranty and Replacement Procedure

TUBE REPLACEMENT

All TWT and BWO tubes furnished in ALFRED instruments are available from ALFRED ELECTRONICS for either warranty or out-of-warranty replacements. Current prices are given on the Replacement Tube Price List.

TUBE WARRANTY

The following warranties are applicable to tubes used in catalog instruments only. For the warranty applicable to tubes used or for use in special or modified instruments, please check with the factory. All tube warranties are from date of shipment by ALFRED.

WARRANTY FOR TWT AND VTM

Tubes are warranted unconditionally against defects in workmanship, materials, and construction within the period shown in Column A and the number of heater hours shown in Column B. To supplement the unconditional warranty, the tubes are warranted on a pro-rata basis for the rated number of heater hours shown in Column C or for one year, both computed from the date of original shipment by ALFRED, whichever expires first. The pro-rated adjustment will be based on the current list price of the tube and the unused percentage of heater hours (Column C) or one-year time period, whichever results in lesser credit.

Warranty Condition*	Tube Type	Applicable Tube Group or Alfred Tube Part No. Series	A Mo.	B Hours	C Hours
WC2	VTM	112-001 and 112-003	2	100	1000
WC3	TWT	10 and 20 mw output except WC4 tubes	12	500	2000
WC4	TWT	112-040 and 112-047	12	2000	-
WC5	TWT	1 watt output except WC6 and WC7 tubes	12	1500	-
WC6	TWT	112-046, 112-065, & 112-072	12	1000	-
WC7	TWT	112-057, 112-080, & 112-081	12	250	1000
WC8	TWT	2 to 10 watt output except WC9 tubes	12	75	500
WC9	TWT	112-055	2	50	500

* WC# denotes the corresponding warranty period(s) shown in the right-hand column(s) and is used for cross-reference to this warranty statement from other documents.

WARRANTY FOR ALL BWO TUBES

Tubes are warranted unconditionally against defects in workmanship, materials, and construction within the period shown below, without regard to the number of heater hours used.

Warranty Condition*	Tube Type	Warranty
WC10	BWO	Warranted unconditionally for one (1) year.

WARRANTY CONDITIONS APPLY ONLY TO TUBES LISTED ABOVE WHICH ARE USED IN ALFRED CATALOG INSTRUMENTS.

This warranty applies only to tubes sold after July 1, 1969.

TUBE SERVICE REPORT

TO OBTAIN WARRANTY CREDIT THE TUBE SERVICE REPORT MUST BE COMPLETED AND RETURNED WITH THE TUBE.

RETURN PROCEDURE

In case a tube or instrument fails, please contact the factory or your local sales representative for advice or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail express. Do not ship via parcel post or air parcel post since experience has shown that fragile items are more apt to be damaged when shipped via these methods.

Use similar wrapping, packing and shipping provisions for an instrument. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

IN-WARRANTY FAILURE - BWO AND VTM TUBES

BWO and VTM tubes which fail in warranty will be replaced with a new tube. In case a tube fails, please issue a purchase order for a new tube at the tube list price and return the defective tube. Warranty credit will be issued and deducted from the price, subject to tube manufacturer's verification that failure was caused by tube malfunction. To qualify for maximum credit, it is essential that the defective tube be properly packed and returned within 30 days after failure.

REPAIRABLE OR IN-WARRANTY FAILURE - TW TUBES

If the returned tube is found to be repairable, the user will be asked to issue a purchase order for repair charges determined by the original tube manufacturer. In general, the repair will be at no cost if the tube is in warranty and there is no evidence of misuse or abnormal conditions of operation.

WARRANTY CREDIT

Any applicable credit allowed under the terms of this warranty applies only toward the purchase of a replacement tube from ALFRED ELECTRONICS. Cash settlements will not be made. In terms of this warranty, a replacement tube must be the same type as that on which credit is allowed. Credit for one tube only may be applied toward the purchase of a single replacement tube. Warranty credit remains in effect for a maximum of six (6) months from date ALFRED ELECTRONICS notifies the customer. All credits will be based on the purchase price of the tube which prevails at the time the order for a replacement tube is received by ALFRED ELECTRONICS.

BWO RF CABLES

RF OUTPUT CABLE MUST ACCOMPANY BWO TUBES returned for warranty credit, repair or replacement. If rf output cable is NOT returned, the cable price is added to the normal BWO repair or replacement charge. For prices see Replacement Tube Price List.

SPECIAL CONDITIONS

If a returned tube or instrument proves not to be defective after test and evaluation at ALFRED ELECTRONICS, the tube or instrument will be returned at the customer's expense.

The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions, lies solely with the tube manufacturer.

Data, warranty credit, and prices subject to change without notice.

ALFRED

8/1/69

SINGER
INSTRUMENTATION

Service Report

Instrument Model _____ Serial No. _____ Date Received _____

TW/BWO Tube Type _____ Serial No. _____ Date Received _____

Date First Tested _____ Date Placed in Service _____ Date of Failure _____

Total Number of Hours of TWT/BWO Heater Operation _____

_____

1. Was operation normal just prior to failure? Yes _____ No _____
2. If not, what was done to adjust it? _____

_____

_____

3. Has proper cooling been maintained during tube operation? _____

_____

4. Did helix overcurrent tripout occur? _____

_____

5. Was environment normal? (specify) _____

_____

6. Symptoms – (describe failure) _____

_____

_____

7. Operating conditions at time of failure (indicate any unusual conditions) _____

_____

_____

8. Name of person to contact regarding evaluation of failure _____

Telephone No. _____ Signature _____

Title _____

Date _____

ALFRED

The Singer Company, Electronic Products Division, Alfred Electronics Operation

3176 Porter Drive, Palo Alto, California 94304 / (415) 326-6496

SINGER
INSTRUMENTATION

Tube Warranty and Replacement Procedure

TUBE REPLACEMENT

All TWT and BWO tubes furnished in ALFRED instruments are available from ALFRED ELECTRONICS for either warranty or out-of-warranty replacements. Current prices are given on the Replacement Tube Price List.

TUBE WARRANTY

The following warranties are applicable to tubes used in catalog instruments only. For the warranty applicable to tubes used or for use in special or modified instruments, please check with the factory. All tube warranties are from date of shipment by ALFRED.

WARRANTY FOR TWT AND VTM

Tubes are warranted unconditionally against defects in workmanship, materials, and construction within the period shown in Column A and the number of heater hours shown in Column B. To supplement the unconditional warranty, the tubes are warranted on a pro-rata basis for the rated number of heater hours shown in Column C or for one year, both computed from the date of original shipment by ALFRED, whichever expires first. The pro-rated adjustment will be based on the current list price of the tube and the unused percentage of heater hours (Column C) or one-year time period, whichever results in lesser credit.

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WC8	TWT	2 to 10 watt output except WC9 tubes	12	75	500
WC9	TWT	112-055	2	50	500

* WC# denotes the corresponding warranty period(s) shown in the right-hand column(s) and is used for cross-reference to this warranty statement from other documents.

WARRANTY FOR ALL BWO TUBES

Tubes are warranted unconditionally against defects in workmanship, materials, and construction within the period shown below, without regard to the number of heater hours used.

Warranty Condition*	Tube Type	Warranty
WC10	BWO	Warranted unconditionally for one (1) year.

WARRANTY CONDITIONS APPLY ONLY TO TUBES LISTED ABOVE WHICH ARE USED IN ALFRED CATALOG INSTRUMENTS.

This warranty applies only to tubes sold after July 1, 1969.

TUBE SERVICE REPORT

TO OBTAIN WARRANTY CREDIT THE TUBE SERVICE REPORT MUST BE COMPLETED AND RETURNED WITH THE TUBE.

RETURN PROCEDURE

In case a tube or instrument fails, please contact the factory or your local sales representative for advice or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail express. Do not ship via parcel post or air parcel post since experience has shown that fragile items are more apt to be damaged when shipped via these methods.

Use similar wrapping, packing and shipping provisions for an instrument. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

IN-WARRANTY FAILURE - BWO AND VTM TUBES

BWO and VTM tubes which fail in warranty will be replaced with a new tube. In case a tube fails, please issue a purchase order for a new tube at the tube list price and return the defective tube. Warranty credit will be issued and deducted from the price, subject to tube manufacturer's verification that failure was caused by tube malfunction. To qualify for maximum credit, it is essential that the defective tube be properly packed and returned within 30 days after failure.

REPAIRABLE OR IN-WARRANTY FAILURE - TW TUBES

If the returned tube is found to be repairable, the user will be asked to issue a purchase order for repair charges determined by the original tube manufacturer. In general, the repair will be at no cost if the tube is in warranty and there is no evidence of misuse or abnormal conditions of operation.

WARRANTY CREDIT

Any applicable credit allowed under the terms of this warranty applies only toward the purchase of a replacement tube from ALFRED ELECTRONICS. Cash settlements will not be made. In terms of this warranty, a replacement tube must be the same type as that on which credit is allowed. Credit for one tube only may be applied toward the purchase of a single replacement tube. Warranty credit remains in effect for a maximum of six (6) months from date ALFRED ELECTRONICS notifies the customer. All credits will be based on the purchase price of the tube which prevails at the time the order for a replacement tube is received by ALFRED ELECTRONICS.

BWO RF CABLES

RF OUTPUT CABLE MUST ACCOMPANY BWO TUBES returned for warranty credit, repair or replacement. If rf output cable is NOT returned, the cable price is added to the normal BWO repair or replacement charge. For prices see Replacement Tube Price List.

SPECIAL CONDITIONS

If a returned tube or instrument proves not to be defective after test and evaluation at ALFRED ELECTRONICS, the tube or instrument will be returned at the customer's expense.

The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions, lies solely with the tube manufacturer.

Data, warranty credit, and prices subject to change without notice.

ALFRED

8/1/69

SINGER
INSTRUMENTATION

Service Report

Instrument Model _____ Serial No. _____ Date Received _____

TW/BWO Tube Type _____ Serial No. _____ Date Received _____

Date First Tested _____ Date Placed in Service _____ Date of Failure _____

Total Number of Hours of TWT/BWO Heater Operation _____

_____

1. Was operation normal just prior to failure? Yes _____ No _____
2. If not, what was done to adjust it? _____

_____

_____

3. Has proper cooling been maintained during tube operation? _____

_____

4. Did helix overcurrent tripout occur? _____

_____

5. Was environment normal? (specify) _____

_____

6. Symptoms - (describe failure) _____

_____

_____

7. Operating conditions at time of failure (indicate any unusual conditions) _____

_____

_____

8. Name of person to contact regarding evaluation of failure _____

Telephone No. _____ Signature _____

Title _____

Date _____

ALFRED

The Singer Company, Electronic Products Division, Alfred Electronics Operation

3176 Porter Drive, Palo Alto, California 94304 / (415) 326-6496

SINGER
INSTRUMENTATION

SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

WARRANTY

ALFRED products are warranted against defects in workmanship and materials. This warranty is limited to repair or replacement of products or parts (except tubes, transistors, and batteries) which prove defective within one year after delivery to original purchaser. ALFRED ELECTRONICS is not liable for consequential damage.

If any fault develops:

1. Notify us, giving full details of the difficulty, including the model number, type number and serial number. Upon receipt of this information, you will be sent service instructions or shipping data.

2. Upon receipt of shipping instructions, forward the instrument prepaid and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins when instrument is not covered by this warranty.

PACKING

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.